Final Report

Development of an Integrated Neonatal Survival and Sustainable Antibiotic Plan

Summary sheet (up to two pages)

Short Title	Development of an Integrated Neonatal Survival and Sustainable Antibiotic Plan		
Start date	01/09/2018	**End date**	31/08/2020
AHDB Project Number	61110070		
HCC Project Number	61110070		
QMS Project Number	61110070		
Project Website Link	N/A		

Project aim and objectives
The aim of this project was to benchmark, define the risk factors for, and propose an integrated control plan to improve survival and reduce morbidity and antibiotic use in neonatal lambs and suckler calves in Great Britain. The core objectives of this project, for both sheep and suckler farmers in GB, were to: 1) Undertake a survey of a representative sample of farmers to describe current neonatal management practices and establish robust benchmarks for mortality and antibiotic use during the antenatal period, the first 24 hours of life, from 1 to 7 days of age and from 1 week to 1 month of age 2) Complete risk factor analysis of the survey data to determine the major drivers of both neonatal mortality and antibiotic use 3) Interview farmers and vets to describe in detail the socio-economic and technological barriers and enablers to recording and acting on mortality and antibiotic use data 4) Provide evidence-based advice for stakeholders in the form of a control plan that integrates knowledge about risk factors and barriers to the adoption of best practice to drive development of tractable management practices For sheep specifically, the objectives were to: 5) Define the impact of ewe metabolic status in late gestation, lamb IgG concentration and oral antibiotic treatment of lambs on lamb performance 6) Describe the relationship between serum total protein and IgG concentration in lambs

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Lead partner	University of Edinburgh
Scientific partners	University of Liverpool, University of Nottingham
Industry partners	Synergy Farm Vets
Government sponsor	N/A

Has your project featured in any of the following?

Due to the COVID19 pandemic, the knowledge exchange components of this project have been postponed. The table below sets out the knowledge exchange activities planned up to December 2021.

Events	Depending on COVID restrictions, three veterinary face-to-face CPD events to be delivered (one for Scotland, England and Wales) by 31st December 2021.
Press articles	None.
Conference papers, presentations or posters	Five abstracts (submitted with this report) were submitted to the British Cattle Veterinary Association Congress 2020, however the conference was cancelled due to COVID19. These will be resubmitted to the next conference. Abstracts will also be submitted to the next Sheep Veterinary Society meeting (Autumn 2020 meeting cancelled due to COVID19). Presentation of study findings at the online SHAWG 2020 conference – 24th November 2020
Scientific papers	Two papers relating to neonatal suckler calf and lamb survival in the journal In Practice. Project findings to be submitted for publication in peer reviewed journals (drafts submitted with this report).
Levy communications	Webinar for vets to be delivered by 31st January 2021. Webinar for levy payers to be delivered by 31st January 2021.
Social Media	To be managed by the levy boards.
Websites	Three video case studies (one for Scotland, England and Wales) to be prepared by 31st July 2021 for the levy board websites.

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Q1 Financial reporting

	Yes	No	N/A
Was the project expenditure in line with the agreed budget?	x		
Was the agreed split of the project budget between activities appropriate?	x		
If you answered no to any of the questions above please provide further details: N/A			

Q2 Milestones: Were the agreed milestones completed on time?

Project milestones	**Proposed completion date**	**Actual completion date**
Survey of current practices		
Develop survey instrument	31/10/18	31/10/18
Distribute survey to levy payers	30/11/18	03/12/18
Run online survey	31/01/19	31/01/19
Descriptive analysis of online survey responses	31/05/19	31/05/19
Student survey of sheep farms	31/05/19	31/05/19
Vet survey of suckler farms	31/08/19	31/07/19
Risk factor analysis		
Risk factor analysis of survey responses	31/12/19	31/12/19
Integration of survey and antibiotic data and analysis	31/12/19	31/12/19
Submission of results for publication	31/08/20	Ongoing

Barrier and enabler interviews		
Develop interview schedule	31/05/19	31/05/19
Conduct interviews	31/10/19	31/12/19
Analyse interviews	31/12/19	31/03/20
Submission of results for publication	31/08/20	Ongoing
Development and pilot of control plan		
Translation of knowledge in dairy sector (DMCP expertise) to beef and lamb systems	31/07/19	30/05/19
Design of control plan	31/12/19	31/12/19
Pilot of control plan on GB farms	31/05/20	31/08/2020
Knowledge exchange, refinement of control plan and generation of final documentation	31/08/20	Delayed
Biological determinants of lamb performance		
Field trial using UoE flock	30/09/19	31/07/19
Measurement of IgG in lamb samples	30/09/19	30/09/19
Statistical analysis of field trial data	31/12/19	31/12/19
Submission of results for publication	31/08/20	Ongoing
Relationship between serum TP and IgG in lambs		
Generation of defined TP cut-offs for inadequate passive transfer in lambs	31/12/19	31/03/20

If any of the milestones above are incomplete/delayed, please provide further details:

The online survey launch was delayed by three days to allow the pilot survey feedback to be obtained and so that a coordinated launch on a Monday morning involving all the levy boards could be achieved.

Due to staff absence, it was agreed following the September 2019 project management conference call that the completion dates for the barrier and enabler interview milestones would be delayed from 31/10/19 (conduct interviews) and 31/12/19 (analyse interviews) to 31/12/19 and 31/03/20 respectively.

The quantification of lamb serum IgG was completed on time, however the results did not provide a satisfactory distribution for the "generation of defined TP cut-offs for inadequate passive transfer in lambs". This work was subcontracted to an external lab who had the same problem initially. After further investigation, they discovered this was because reagents had been shipped at room temperature, rather than at 4^{o}C. We cannot prove that this was the same problem that affected our assay (i.e. we can't get a refund on reagents), however we suspect that this explains why the first attempt of this work was not successful. We now have a complete set of IgG results and have completed this milestone.

Due to the COVID19 pandemic, the knowledge exchange components of this project will have to be delayed. A no cost extension until December 2021 has been agreed to allow the knowledge exchange activities to take place when social distancing rules have been relaxed. The activities will be reconfigured as follows:

1) Presentation of the project findings to the Sheep Veterinary Society (SVS) and British Cattle Veterinary Association (BCVA) at the next BCVA and SVS conferences. Dates to be confirmed by SVS & BCVA.
2) Two In Practice papers
3) Two webinars to be delivered in January 2021 to disseminate the key findings of the project:
    i. Aimed at vets
    ii. Aimed at farmers
4) The 12 face-to-face events to be repackaged as:
    i. Three professional quality video case studies by July 2021
    ii. Provision of quality assured CPD training for vets
    iii. Three CPD face to face events (2021)

Manuscripts have not yet been submitted to journals. Two drafts are included with this report for review by the levy boards with a view to submission if agreed by the levy boards.

Q3 Results: What did the work find?

Key findings

Neonatal survival

- Median GB lamb mortality in first 21 days of life: 8.2% (top quartile 6%)
- Median GB suckler calf mortality in first 21 days of life: 4.4% (top quartile 2.5%)
- Majority of mortality in lambs (8.1%) and calves (4.0%) occurs in the first 7 days of life
- Mortality rates do not vary by farm size or number of breeding females per full time equivalent staff member
- Farmer reported mortality rates in one season do not correlate with observed mortality rates in the subsequent season
- Most suckler farmers have access to reliable mortality records, however 2 in 5 sheep farmers have no record of neonatal mortality at all
- Best practice industry advice with respect to managing neonatal mortality is not consistently followed, particularly with respect to colostrum management and genetic selection

Social sciences

- Neonatal survival is important to farmers
- Farmers demonstrate autonomous motivation to improve neonatal survival and feel confident in their abilities
- Farmers tend to underestimate neonatal mortality on their farm relative to GB averages
- There is a cultural stigma around neonatal losses, which limits farmers in discussing their experiences with their peers and even in some cases, with their vet

Antibiotics

- Reductions in the use of preventive oral antibiotics in lambs are challenging, as their use has historically been viewed as a part of best practice in avoiding losses. However, preventive antibiotics have been reduced or withdrawn successfully on some farms
- Oral antibiotic treatment at birth in a well-run flock does not improve lamb outcomes
- Beef and sheep farms are able to manage infectious disease without purchasing fluoroquinolones, 3rd/4th generation cephalosporins or colistin

Nutrition and colostrum

- Poor long term protein status in late pregnancy (low blood albumin) is predictive of increased lamb loss between scanning and 24 hours old
- Twin born lambs with a serum antibody (IgG) concentration under 24 mg/ml are more likely to have poorer growth rates
- Poor energy balance in late pregnancy (elevated beta-hydroxybutyrate) is predictive of a lamb serum antibody (IgG) concentration under 24 mg/ml
- Lambs supplemented with colostrum are at increased risk of having a serum antibody (IgG) concentration under 24 mg/ml

Online questionnaire, farm data and risk factor analysis

Farm background and headline mortality rates

A total of 1788 people accessed the online questionnaire. Of these, 384 (21%) progressed beyond the landing page, and 214 (11% of those who initially accessed the questionnaire) completed the questionnaire. Figure 1 shows the locations of the questionnaire participants by county.

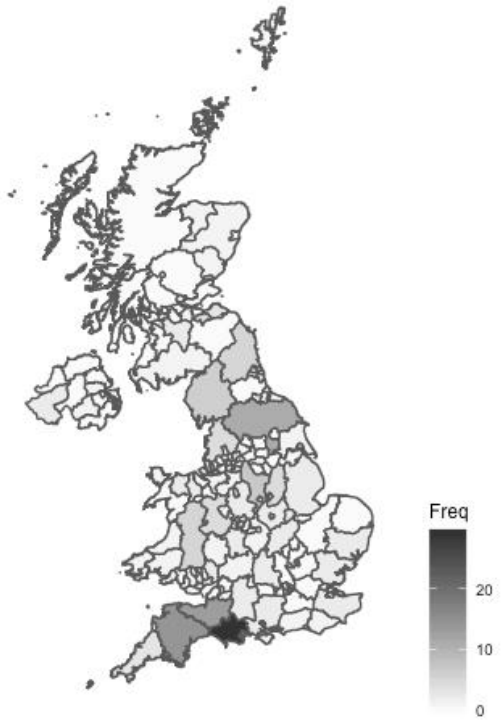

Figure 1: Distribution of questionnaire respondents by county

Eleven responses were excluded because they did not have a GB suckler or lambing ewe flock, giving a total of 203 responses. Of these, 23 (11%) had a suckler herd, 125 (62%) had a lambing ewe flock, and 55 (27%) had both a suckler herd and lambing flock.

A total of 113 sheep flocks and 31 suckler herds were recruited by their vets or lambing students to supply lambing and calving data in spring 2019. Two of the sheep farms recruited through students did not submit any information about their farm practices. These two farms were removed from further analysis, making the total number of sheep farms 111. Twelve of the farms contributed data about both their suckler herd and ewe lambing flock, all of whom were recruited through their vet. The total number of farms from which detailed data was collected was 130 (99 sheep only, 12 sheep and suckler, 19 suckler only), therefore of the 203 online questionnaire responses, only 71 originated from the questionnaire distributed nationally by the levy boards. Due to this poor response rate, all subsequent analysis focusses on the 130 farms that were recruited through their vets or lambing students. The advantage to this is that the subsequent

analysis of survival and mortality is based on data recorded on farm in 2019, however it is important to note that 2018 survival and mortality data are based on data reported by the farm and are hence affected by recall bias. The same is true for data relating to management practices, which were reported online by the farm and hence are dependent on their recollection at the time of being surveyed.

Of the sheep flocks, 24 (21%) were recruited through their vet and the remainder through a student placement. Those sheep farms monitored by students contributed, on average, 10 days of data (minimum of 2 and maximum of 27 days), and those sheep farms monitored by their vets contributed, on average, 72 days of data (minimum of 41 and a maximum of 112 days). Cattle farms contributed, on average, 102 days of data (minimum of 35 and maximum of 168 days). Table 1 summarises the characteristics of the farms that submitted lambing or calving data in spring 2019. Flocks were distributed nationally, however the suckler herds were almost all located in south-east Scotland and south-west England. The average herd and flock sizes in the study were larger than the GB reported average of 28 breeding cows and 221 breeding ewes reported by DEFRA for 2019[1]. The sheep flocks in the study were located in both less favourable (hill and upland) and lowland farming areas. However, all but one of the cattle herds were located in lowland areas. 19% of the suckler herds and 5% of the sheep flocks were certified organic.

Calves were at a lower risk of neonatal mortality than lambs. In both species, the majority of the mortality up to 21 days old occurred in the first 7 days of life. The 21-day mortality rate in lambs ranged from 1 to 60%, but only six lambings in total were recorded on the farm that reported a 60% mortality rate and only six farms had mortality rates higher than 20%. For cattle, the 21-day mortality rate varied between 0 and 28%, with four farms (12% of those contributing data) reporting rates higher than 10%.

Of the 111 lambing flocks, 13 (12%) reported requiring at least 1 caesarean section to correct dystocia during the period over which they were observed. Of the 31 suckler herds, 4 (15%) reporting requiring a caesarean section during the calving period.

The median percentage of the ewes that died during the observed period was 1.5% (IQR 0.4-2.7%). 19 flocks (17%) did not lose any ewes during the observation period. For the suckler herds, 21 farms (67%) did not lose any cows during their calving period. For the remaining 10 farms, the percentage of dead cows ranged from 0.7 to 5.2%.

1 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/955333/structure-june-UKsizebands-25jan21.ods

Table 1: Key data for herds and flocks providing 2019 lambing and calving data.

	Suckler	Sheep
Total flocks or herds involved in study	31	111
Hill	0	7 (6%)
Hill / Upland	0	11 (10%)
Upland	1 (3%)	17 (15%)
Upland / Lowland	1 (3%)	2 (2%)
Lowland	27 (87%)	61 (55%)
Organic	6 (19%)	6 (5%)
Size of farm (mean no. acres)	546.4	530.7
Number breeding animals reported (median and IQR)	61 (39-105)	531 (291-873)
Number of animals per full time equivalent (median)	38	165
Number dams calved / lambed during study (mean)	63	248
Number animals born during study (mean)	63	397
Lambing / calving percentage (median and IQR)	102% (100-103%)	165% (147-188%)
Mortality up to 21 days old (percent of number born) (mean / median (IQR))	6.6% / 4.4% (2.5-7.7%)	10.4% / 8.2% (6.0-12.9%)
Mortality up to 7 days old (percent of number born) (mean / median (IQR))	5.4% / 4.0% (2.2-6.0%)	9.5% / 8.1% (6.0-12.8%)

Where percentages do not add up to 100% it is because farms did not provide adequate information to place them in a category. Farms that had suckler cows and sheep on the same farm feature in both columns.

Breeding

A range of bull breeds were used by the suckler herds in the study. No difference in mortality was observed between herds using predominantly native or continental breeds, whist only two herds used composite breeds (e.g. stabiliser). Due to the popularity of the Angus, it was possible to look at mortality for Angus herds separately. Again, there was no difference between mortality in Angus versus native or continental breeds.

When asked about their breeding practices, 38% of lambing flocks reported using estimated breeding values (EBVs) to select their rams, and 41% of suckler herds reported taking calving ease into account when selecting their bulls. We were unable to identify an association between the use of EBVs and lamb or calf mortality. This is likely a consequence of the many farm level factors that impact on neonatal mortality, that due to the size of this study, we were unable to control for, rather than the lack of an association. The more striking interpretation of this data is that only around 2 in 5 farms in this study used EBVs, despite this being considered good industry practice.

Around two thirds of suckler herds reported using pregnancy diagnosis (PD) in their cows, and two thirds of these reported to go on to cull barren cows. Those herds that do not PD or cull had the highest calf mortality, and those that carried out both had the lowest calf mortality (Table 1 and Figure 2). Whilst the herd numbers are small, this association is quite striking, with farms

reporting that they performed pregnancy diagnosis and culled having less than half (4.8%) the mortality of herds that didn't pregnancy diagnose and cull (12.2%). This study cannot establish a causal relationship and this practice may be associated with other farm management practices that improve survival, however the difference of seven additional live calves per 100 cows is striking and at £700 per store calf, would represent an additional income of £4,900 per 100 calves at the end of the year.

Table 1: Predicted calf mortality depending on whether farms routinely used pregnancy diagnosis to manage culling in their herds

PD and culling practice	Number of herds	Predicted mortality	Lower CL	Upper CL
No PD No Cull	5	12.2%	8.2%	17.6%
PD No Cull	7	7.8%	5.2%	11.5%
No PD but report cull	5	6.4%	4.1%	9.8%
PD and Cull	14	4.8%	3.8%	6.2%

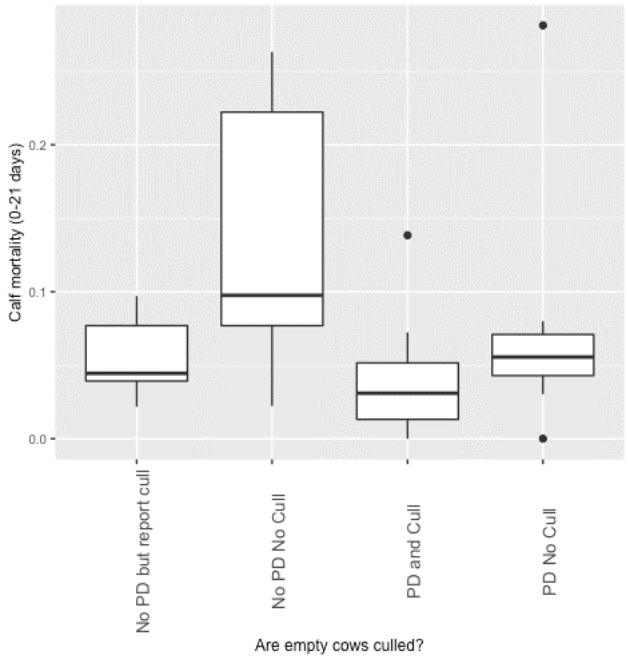

Figure 2: The relationship between pregnancy diagnosis ± culling of empty cows and suckler calf mortality

There was no relationship between mortality and flock/herd size (Figure 3) or the length of the lambing and calving period (median lambing period 41 days (IQR 30-51 days) and calving period 83 days (IQR 73-111 days)).

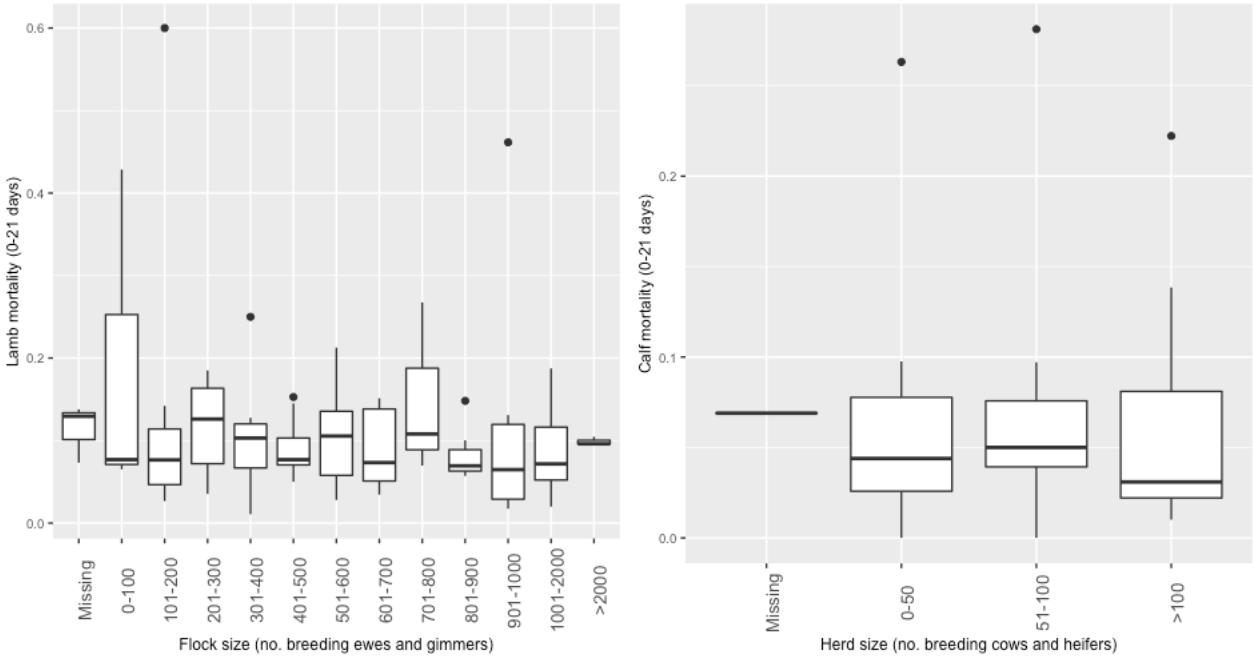

Figure 3: The relationship between the number of breeding females and lamb and calf mortality.

Nutrition

90% of sheep flocks and 70% of suckler herds reported body condition scoring at least some of their ewes or cows, 9% of flocks and 23% of suckler herds reported carrying out metabolic profiling, and 34% of flocks reported carrying out some sort of ration management through the advice of a nutritionist or getting forage analysed or both. It was reassuring to see a high proportion of participants making use of body condition scoring, however with only 1 in 3 farms making use of a nutritionist and/or forage analysis, there is still some way to go with respect to consistent rationing, which is impossible to achieve in the absence of forage analysis. We were unable to identify an association between these practices and lamb or calf mortality. As with EBVs, this is likely to be a consequence of the many farm level factors that impact on neonatal mortality, that due to the size of this study, we were unable to control for, rather than the lack of an association.

Colostrum

Farms were asked to report how much colostrum they routinely gave to calves or lambs when providing them with supplementation. 74% of flocks and 90% of suckler herds reported to be supplementing lambs and calves with less than the industry recommended 200 ml for lambs and 4 L for calves to be fed within 2 hours of birth (Figure 4). This highlights the difficulty in implementing best practice colostrum management on farms. Whilst this was not explored in more depth in this study, these findings are consistent with anecdotal reports that many farmers feel that these recommended volumes are too ambitious. It is important to note that the 4 L industry standard for calves is based on an average suckler calf birthweight of 40 kg and the recommendation that 10% of birthweight is fed. There is a concerted industry initiative to focus on delivering the appropriate Quantity of high Quality colostrum Quickly (the 3 Qs). In the

context of beef and sheep production, delivering an appropriate quantity of dam's colostrum quickly is the main challenge. There is limited evidence of problems with poor colostrum quality in beef and sheep production, with this mainly being an issue of colostrum antibody dilution in high yielding Holstein dairy cows. Colostrum quality is however a consideration if farmers are making use of donor colostrum from dairy herds or commercial powdered colostrum supplements. This was not explored in this project, but has been examined in depth in other recent work funded by AHDB and the University of Edinburgh. We did not find a correlation between the colostrum volume reported to be routinely fed and the amount of mortality observed on farms, however this is not surprising, given that other factors relating to colostrum management are likely to affect this relationship e.g. type of colostrum used and speed of feeding after birth.

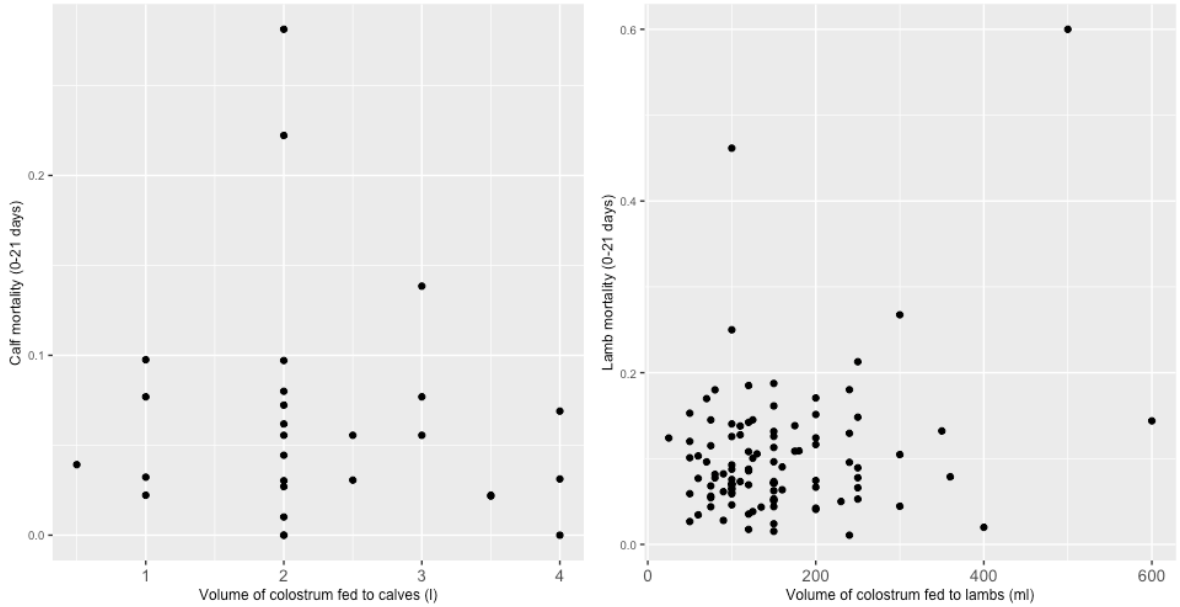

Figure 4: The relationship between the volume of supplementary colostrum fed and calf and lamb mortality.

Infectious disease management

Of the 92 sheep farms in the study that reported their vaccine use, 83% reported using a clostridial vaccine in pregnant ewes prior to lambing. 41% reported using a vaccine against enzootic abortion and 39% reported using a vaccine against toxoplasmosis. It is likely that farms make vaccine decisions based on the previous history of disease problems in the flock or their trading practices. As this study did not seek to determine the disease status of each flock (e.g. through the use of serology or abortion/post mortem investigations), it is not surprising that we didn't find an association between vaccine practices and lamb mortality.

Of the suckler farms, 16% reported using a vaccine against Infectious Bovine Rhinotracheitis (IBR), 35% reported using a vaccine against leptospirosis, and 58% reported using a vaccine against Bovine Viral Diarrhoea (BVD). Those farms that reported using a BVD vaccine had a lower median mortality of 3.1% (IQR 2.2-6.6%), whereas those that did not vaccinate reported a

higher median mortality of 6.2% (IQR 3.9-9.7%). Just three herds (10%) reported using a vaccine in pregnant cows to protect calves from scour. In this case, those that did report using a calf scour vaccine had a higher median mortality of 6.9% (IQR 4.0-10.8%) and those that didn't had a lower median mortality rate of 4.2% (IQR 2.6-7.7%). There was no statistical difference between herds that vaccinated and herds that did not, which could be a consequence of the small number of herds in this study. The trend for higher mortality in herds using scour vaccines could represent ongoing difficulties with scour in these herds, however future work is required to determine whether this trend is statistically significant and if so, whether mortality would be higher in these herds in the absence of the use of vaccines. It is worth noting that calf scour is caused by a variety of different pathogens, of which only three can be controlled via vaccination (*E. coli*, rotavirus and coronavirus).

Farmers were asked to describe how they managed the housing and bedding of cows around calving time (Figure 5). Suckler herds that reported moving cows before calving reported higher calf mortality (7.8%, 6 farms, CI 5.6-10.8%) than those that moved cows and calves 24 hours after calving (3.6%, 9 farms, CI 2.3-5.7%). The remaining farms did not report moving cows in the perinatal period. Of the 14 suckler farmers that provided information on straw yard management, 10 reported bedding down daily, 2 reported bedding weekly and 2 only when the cattle were dirty. The two herds that bedded down when the cattle were dirty both had mortality rates of above 10%.

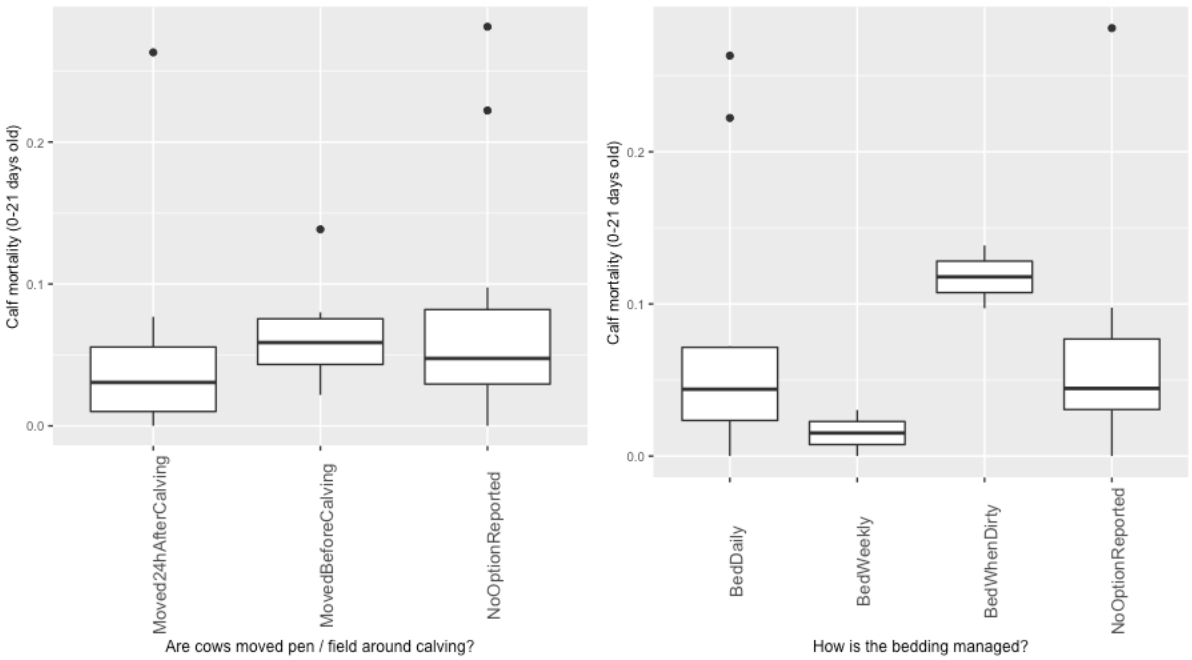

Figure 5: The relationship between group management and bedding around the time of calving and calf mortality.

Of the participating sheep farms, 54% reported wearing disposable gloves for lambing. It is striking that only half of farmers are adhering to this practice. Unsurprisingly, this behaviour was not correlated with lamb mortality, as the primary function of glove wearing during lambing is to

protect the ewe and the farmer. Suckler farms did not report on whether they wore gloves for calvings.

Shelter

There was a trend of higher mortality in lambs born outdoors compared to indoors (Figure 6), however this difference was not statistically significant. The mixed systems in this study were predominantly flocks that kept ewes still to lamb outside during the day (weather allowing) and inside overnight, which is a practice that is anecdotally associated with lowland flocks. Again, there was a non-significant trend towards higher mortality in these mixed systems compared with indoor lambing. For suckler farms, there was no relationship between calving indoors versus outdoors and calf mortality.

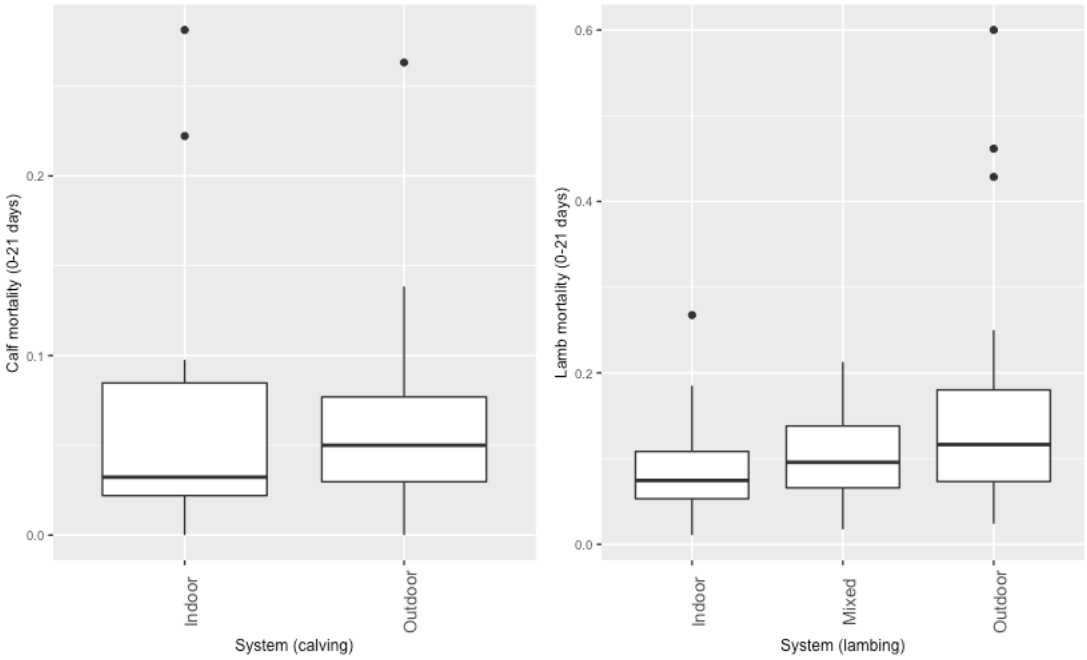

Figure 6: Calf and lamb mortality to 21 days old by calving and lambing location

Multiple correspondence analysis

To determine whether specific husbandry practices clustered within farms and whether this was related to mortality rates, multiple correspondence analysis was undertaken for the husbandry practices on sheep farms and their association with each other, and the supplementary variable, lamb mortality (Figure 7).

Unfortunately, the two dimensions of the MCA only explain 27% of the variance in the data, whilst clustering was generally weak and none of the axes strongly correlated with mortality rates, with these placed, in the main, close to the centre of the plot.

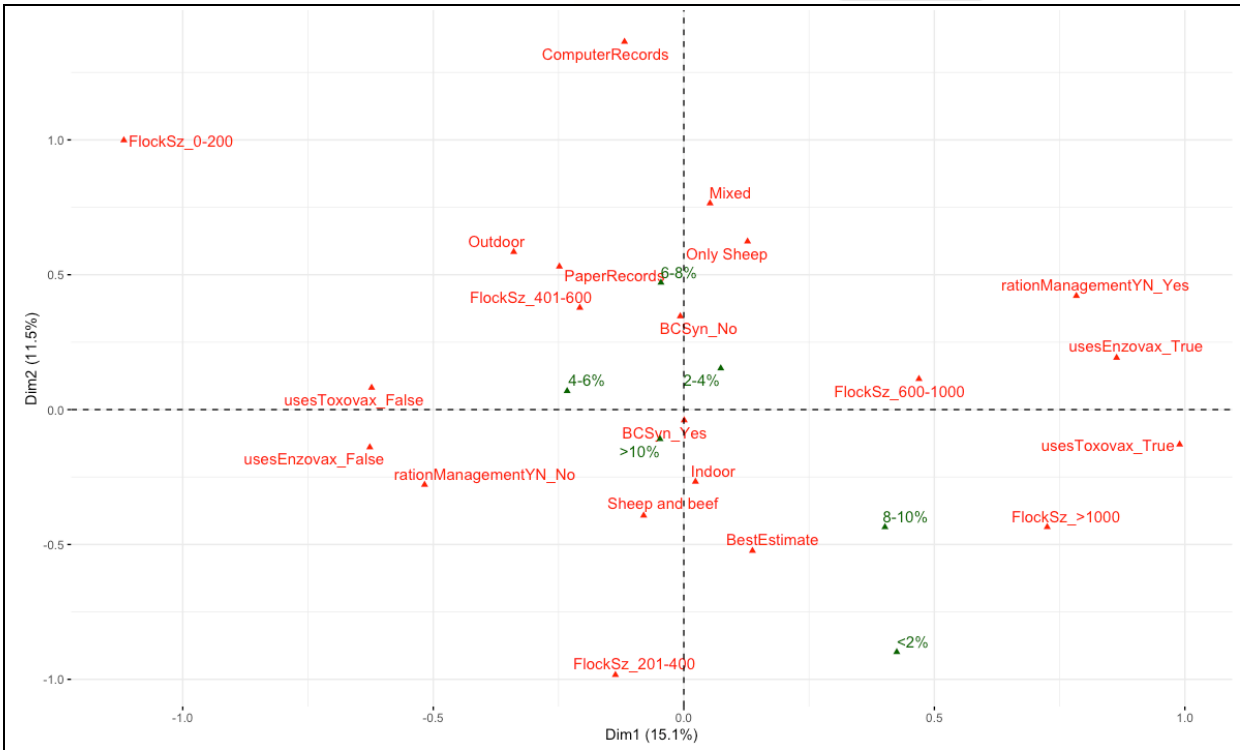

Figure 7: Multiple correspondence analysis investigating the association between husbandry practices on sheep farms. Lamb mortality is plotted as a supplementary variable in green.

Perceived causes of lamb and calf losses

To explore the factors that farmers perceive to be driving mortality, respondents were asked to report the problems that they recognised as causing losses in their lambs and calves**Error! R eference source not found.**. For lambs under 7 days old, starvation, predation, and exposure were reported as causes of death by over half the outdoor lambing flocks surveyed (Table 3), whilst watery mouth was the only cause of death reported by over half of indoor lambing flocks (Table 4). Starvation and exposure were still recognised by a significant proportion of indoor lambing flocks, whilst accidents were recognised by more indoor than outdoor lambing flocks (35% versus 14% farms). Lambing injuries were recognised as a cause of loss in a similar proportion (1 in 5) of indoor and outdoor lambing flocks.

In lambs 7-21 days old, starvation, joint ill and predation were recognised as causes of loss by a similar proportion of indoor and outdoor lambing flocks, although exposure was recognised by a slightly higher proportion of indoor lambing flocks (38% versus 28% farms). In lambs over 21 days old, worms, pneumonia and clostridia were recognised as causes of loss by a similar proportion of indoor and outdoor lambing flocks, but curiously, joint ill was recognised by a greater proportion of outdoor lambing flocks in this age group (21% versus 12%).

Around half of suckler herds recognised losses associated with calving injury, and around a quarter reported losses due to scour. Interesting, pneumonia was recognised by a similar proportion of suckler and sheep farmers, despite the relatively limited industry attention to pneumonia in lambs compared to calves.

Table 3: Proportions of farmers reporting different perceived causes of lamb loss in outdoor lambing flocks. Causes reported by more than 20% of flocks are highlighted.

	Lambing Injury	Accident	Starvation	Exposure	Navel Ill	Joint Ill	Watery Mouth	Scour	Worms	Pneumonia	Clostridia	Predation
Less than 7 days old	0.21	0.14	0.66	0.72	0.10	0.03	0.38	0.14	0.00	0.03	0.03	0.52
7 to 21 days old	0.00	0.14	0.34	0.28	0.10	0.24	0.07	0.00	0.00	0.03	0.03	0.24
21 days to weaning	0.00	0.17	0.10	0.07	0.03	0.21	0.00	0.00	0.21	0.21	0.17	0.17

Table 4: Proportions of farmers reporting different perceived causes of lamb loss in indoor lambing flocks. Causes reported by more than 20% of flocks are highlighted.

	Lambing Injury	Accident	Starvation	Exposure	Navel Ill	Joint Ill	Watery Mouth	Scour	Worms	Pneumonia	Clostridia	Predation
Less than 7 days old	0.20	0.35	0.36	0.40	0.04	0.04	0.54	0.09	0.00	0.04	0.01	0.16
7 to 21 days old	0.03	0.17	0.35	0.38	0.04	0.24	0.05	0.07	0.00	0.10	0.01	0.27
21 days to weaning	0.00	0.15	0.09	0.07	0.03	0.12	0.00	0.09	0.22	0.29	0.23	0.10

Table 5: Proportions of farmers reporting different perceived causes of calf loss in spring calving herds. Causes reported by more than 20% herds are highlighted.

	Calving	Exposure	Starvation	Scour	Navel Ill	Pneumonia	Accident	Bloat
Less than 7 days old	0.52	0.04	0.20	0.04	0.08	0.00	0.16	0.00
7 to 21 days old	0.00	0.00	0.00	0.24	0.08	0.12	0.00	0.00
21 days to weaning	0.00	0.00	0.08	0.00	0.04	0.20	0.12	0.04

Data recording and management

One of the major challenges to improving neonatal survival in suckler calves and lambs is the lack of reliable data collected by farmers. To explore this in more detail, farmers were asked to report their levels of mortality in 2018 and were asked how they produced the numbers they reported. 61% of suckler farms and 25% of lambing farms reported making use of paper records to answer the questionnaire, 19% of sucker farms and 11% of sheep farms used computer records, and 16% of suckler farms and 64% of sheep farms provided their best estimate from memory.

When asked more generally about the way they recorded losses on the farm, all cattle farmers reported keeping a record of all losses on paper (54%) or on the computer (45%). All cattle movements in GB, including births and deaths, must be recorded and reported to the British Cattle Movement Service, and hence this is not surprising for suckler farms. Sheep farmers are not required to submit such data and 37% of sheep farmers reported keeping no records on losses at all.

The calf and lamb mortality figures reported by the farmers for 2018 were compared to the observed mortality recorded by the vets and veterinary students in 2019 (Figure 82). For a small number of farms, there was good congruence between the two, however overall there was no correlation between the mortality rates between the two years.

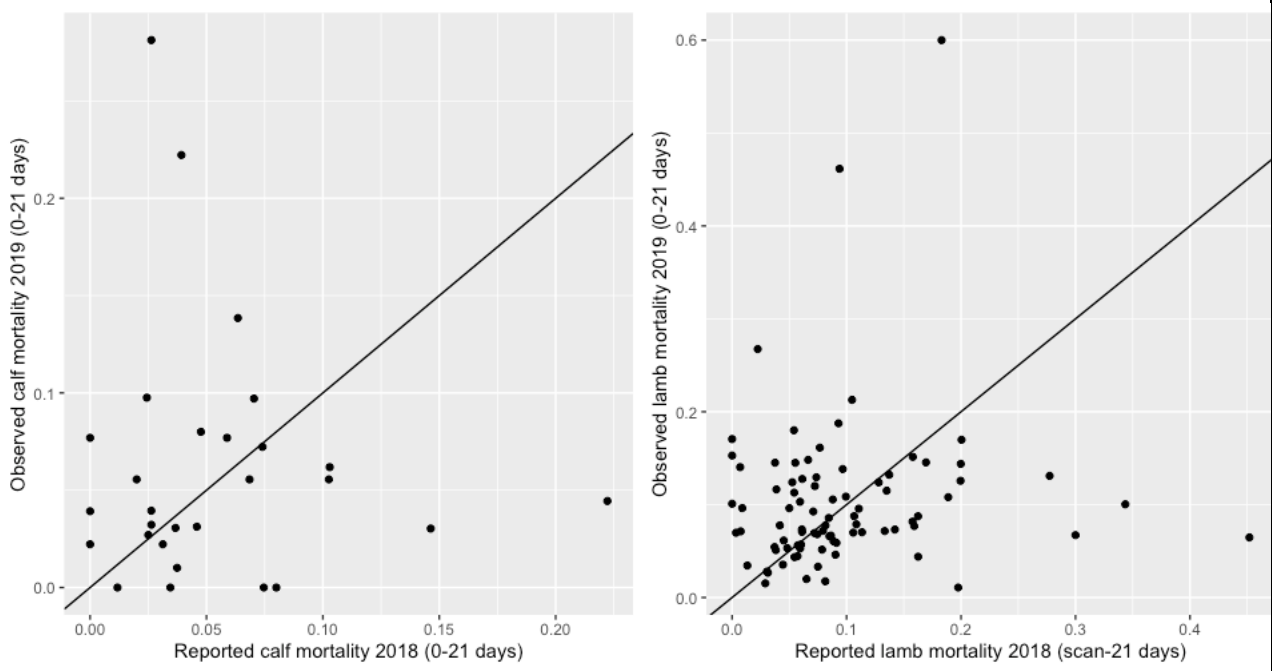

Figure 82: Comparison of the reported calf and lamb mortality (0-21 days) in 2018 to the observed mortality in 2019.The black line represents a perfect correlation between the 2018 and 2019 mortality rates.

Farm team and opinion of competence

In an attempt to examine the relationship between staffing and neonatal mortality, the number of full-time equivalent (FTE) staff members per breeding female was calculated. This was not corrected for whether the farms had both ewes lambing and cows calving at the same time. Farms reported having a median of 165 ewes and 38 cows per FTE. There was no relationship between FTE and calf or lamb mortality, however, the suckler farms that also had a lambing flock reported higher calf mortality in the first week of life than suckler farms where there was no lambing flock. The predicted mortality for those suckler farms with sheep was 7.3% (95% CI 6.1-8.7%), and for those without sheep was 2.2% (95% CI 1.1-4.2%). The same was not seen with lamb mortality, with sheep only farms having a median lamb mortality of 7.8%, and mixed farms having a median lamb mortality of 9.5% (Figure 9). This could suggest that in farms with cattle and sheep, more time is devoted to the ewes, than the cattle, or may represent a difference in the expertise of the farmers i.e. a bias towards expertise in managing the lambing ewe in comparison to the calving cow.

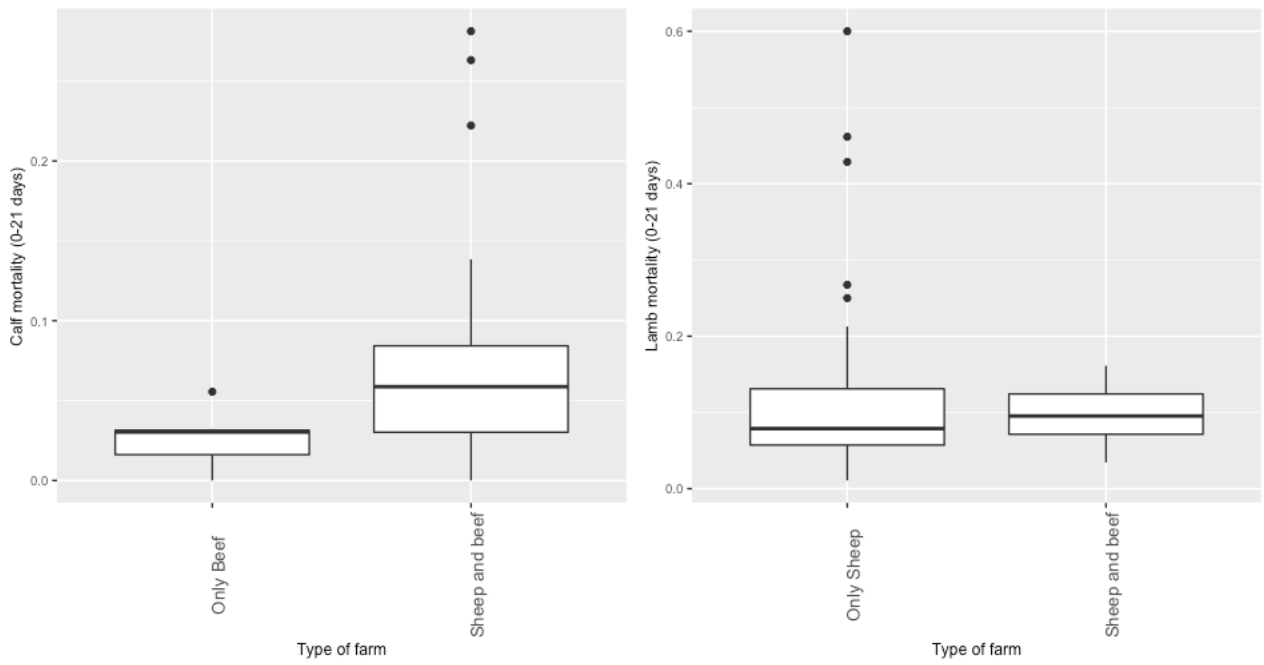

Figure 9: Comparison of calf and lamb mortality between sheep only, suckler only, and mixed species farms.

To explore whether there was a relationship between the farmers' perception of their own performance and their observed performance in 2019, farmers were asked to use a seven point Likert scale to indicate how much they agreed with the statement, *Neonatal survival in my herd / flock is better than average*. In aggregate, the responses to this question were evenly distributed, with 50% reporting that they disagreed and 50% reporting that they agreed with the statement. Once plotted against the farm's actual survival (Figure 10), sheep farmers' increasing belief that their farm was better than average largely mapped to improved performance, with the exception of those that were most confident, where there was a noticeable deterioration in

performance. The pattern for cattle farmers was less clear, most likely due to the small number of participating farms.

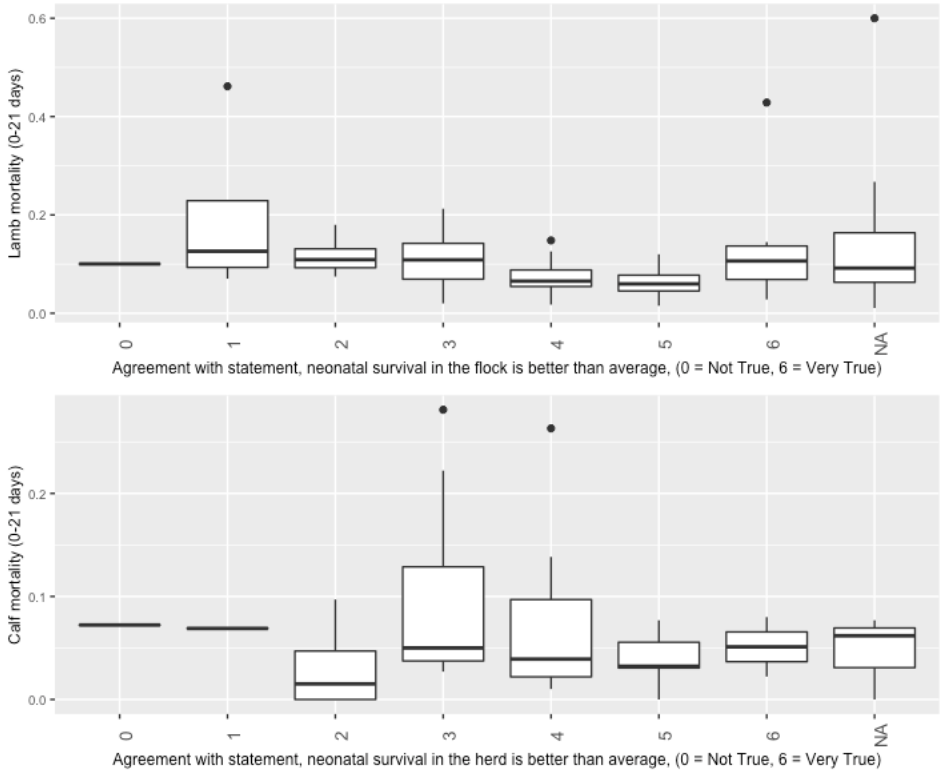

Figure 30: The relationship between lamb and calf mortality and farmers' reported belief that their neonatal survival is better than average. NA indicates the farmers that gave no answer to this question.

<u>Attitudes, perceptions and practices</u>

The question relating to competence (Figure 10) was part of the final section of the online questionnaire, which asked about attitudes, perceptions and practices relating to neonatal survival. The theoretical framework underlying these questions is Self-Determination Theory, a theory from psychology about what motivates people to take action. Validated survey instruments to assess motivation for health behaviours were adapted to develop the survey questions to measure perceived competence and motivation. These questions aimed to determine how much control the respondents felt that they have over neonatal survival, and whether the actions that they take were motivated by their own choices or external pressures. Open questions were also included to elicit free-text responses relating to current practices. To make maximum use of this data, all 251 completed surveys were analysed.

Are neonatal losses important to farmers?

Neonatal losses are a concern, but the responses are quite mixed (Figure 11). It may be that those who have experienced more severe neonatal losses are more concerned, while those with fewer issues do not see it as a concern in their flock or herd. However, neonatal survival is

considered to be important for business success. Slightly more respondents felt that their neonatal survival was better than average (see discussion above).

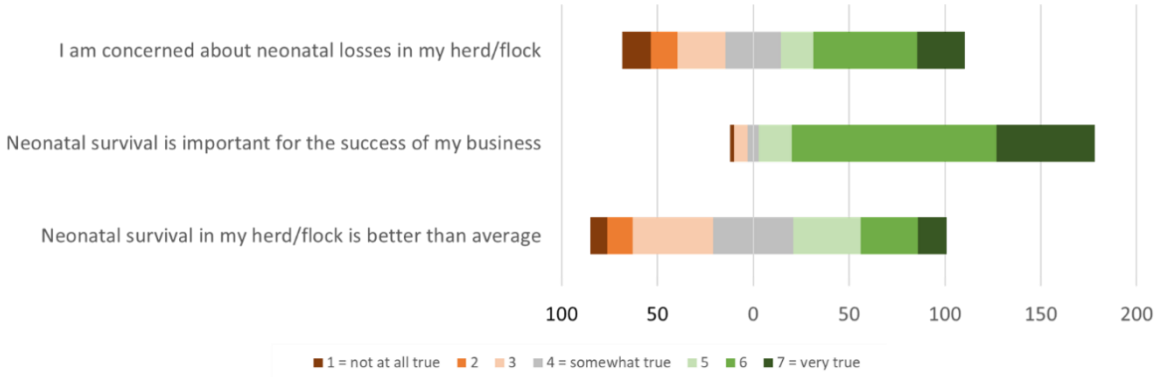

Figure 11: Attitudes towards neonatal losses

Do farmers feel that they can influence neonatal survival?

The majority of respondents feel that they are able to improve neonatal survival through their actions (Figure 12). However, this is not universal, and farmers with lower levels of perceived competence need support to have confidence in their ability to reduce losses.

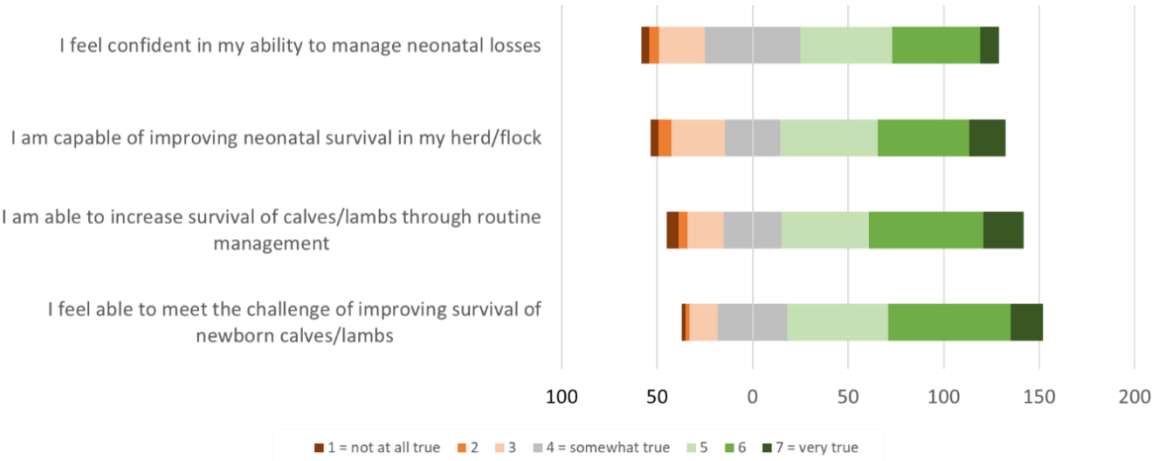

Figure 12: Perceived competence to improve neonatal survival

What do farmers do to reduce neonatal losses?

Many of the main actions described are linked to a particular stage of the breeding cycle i.e. breeding and pregnancy, parturition and neonatal care, while good husbandry, a well-managed environment, and good veterinary care apply at all stages. There is also considered to be an element of luck in those factors that are beyond the farmer's control, such as the weather. The responses indicate that farmers' current practices to improve neonatal survival are part of an ongoing process throughout the production cycle for beef cattle and sheep (Figure 13).

Respondents were also asked “Are there other actions that you would like to take to increase neonatal (first month of life) survival in your herd/flock, but don't at present?” The themes identified in the responses to this question were very similar to those around current actions, only with a desire to “do better” e.g. better housing, better hygiene, more staff. However, one of the most frequently occurring themes was “nothing” – as in there are no additional actions that they would like to implement, suggesting that they feel they are doing all that they can at present.

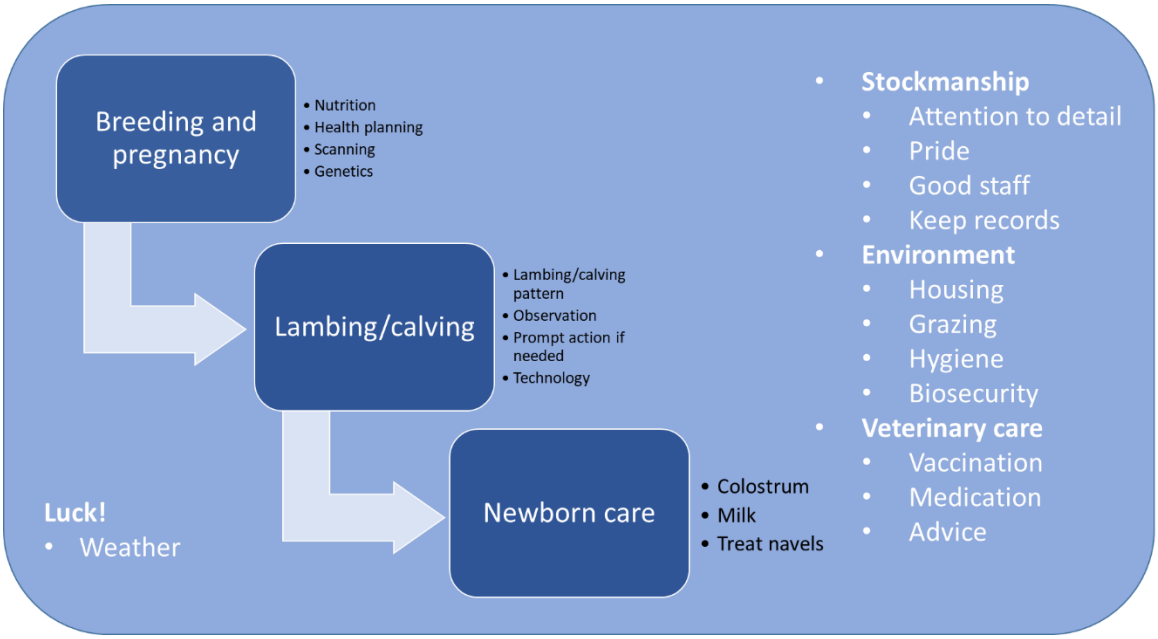

Figure 13: Actions taken to improve neonatal survival

Why do farmers do what they do?

Autonomous motivation is stronger overall than controlled motivation i.e. farmers take action to reduce neonatal losses because they want to more than because they feel that they have to due to external pressure (Figure 14). The controlled motivation statements that relate to internalised responses (i.e. how farmers would feel about themselves) are stronger motivators than fully extrinsic factors such as the opinions of others.

Veterinary advice was considered to be the least relevant motivator overall, but this is not to say that the farm vet doesn’t have an important role to play in supporting efforts to reduce losses – simply that farmers don’t generally take action to reduce losses just because their vet has told them to do so. These findings indicate that there is already a high level of autonomous motivation to reduce losses among many farmers, and that a control plan should support this further, as autonomously motivated actions are more likely to be sustained. This has relevance to how vets approach discussions, which needs to acknowledge that farmers are already strongly motivated to improve neonatal survival.

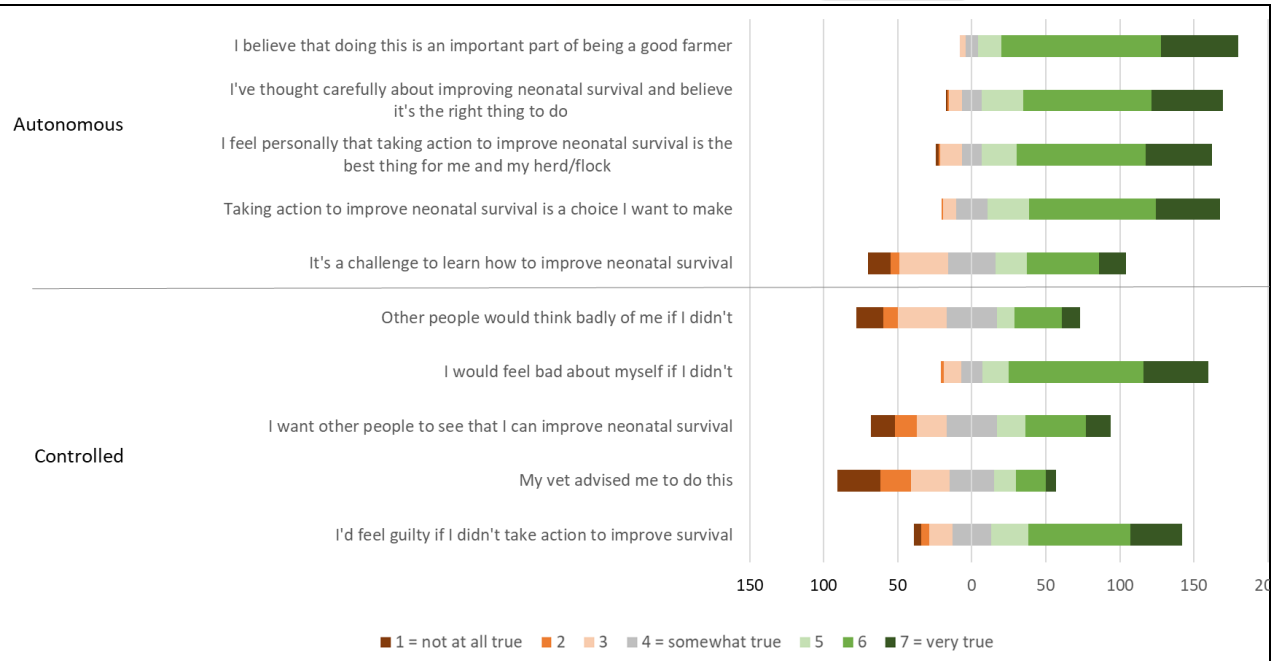

Figure 14: Responses to the statement "I take action to improve neonatal (first month of life) survival because..:"

Open questions

A summary of themes identified from the responses to the question “What motivates you to take these actions?”, following the question “What are the main actions you take to increase neonatal (first month of life) survival in your herd/flock?” is presented in Figure 15.

	Intrinsic	Extrinsic
Positive	Knowledge and understanding Being a good stockman Pride Responsibility Job satisfaction Ambition	Money Results Easy to do Animal welfare Animal health Improve survival Productivity Natural approach
Negative	Fear Guilt Stubbornness	Avoiding losses Less trouble Family pressure Avoid buying in replacements Avoid fallen stock costs
		Weather* Data* Herd history*

*These factors were cited as motivators, but it is not clear whether they are positive or negative.

Figure 15: Motivators to take action to reduce neonatal losses

Barriers

The most frequently cited barriers to taking additional actions were cost, time, facilities such as housing and labour shortages. The barriers to implementing further measures to reduce losses were almost all extrinsic. Several respondents also mentioned a lack of knowledge.

Barrier and enabler interviews

The farmers interviewed included those with pedigree and commercial herds and flocks in primarily lowland areas, with cattle only, sheep only or both species. The participating veterinary practices included covered both upland and lowland farming areas. The vets interviewed provided insight into their role in preventing and addressing neonatal losses, as well as a broad overview of the issues faced by their beef and sheep clients, while the farmers provided more detailed information about their own herd or flock and direct experiences around neonatal losses. Several of the vets had worked in other practices in different areas of the UK, and spoke of their experiences in both their current and previous roles, which further extended the geographical range of the data. There was significant overlap in the role of the vet and farmer, as many of the vets interviewed had their own family farms, and some of the farmers had family members who were vets or had further training in animal health.

Defining neonatal losses

There was no universally accepted definition among the participants of “neonatal losses” in terms of clear cut-off minimum and maximum ages at which a lamb or calf is considered to be a neonate. This ambiguity around defining neonatal losses was identified from preliminary discussions within the project team and explored further in the interviews by asking each interviewee to provide their own definition of a neonatal loss. Across all of the interviews, definitions varied to include abortions at any point from scanning onwards through to deaths of lambs and calves up to weaning. However, birth and the first 48 hours of life were generally agreed to be the neonatal period by all participants. There was some debate around whether a stillbirth should be counted as a neonatal loss. Participants’ opinions were divided, with some saying that they include all stillbirths in their definition, while others felt that there was a distinction between a lamb or calf born dead and one that was born alive but died shortly afterwards. Once the lamb or calf was up and suckling and bonded with its mother, this was felt by many to be the end of the immediate neonatal period. In indoor systems, turnout marked a clear end to the neonatal period where the farmer’s influence on survival became more limited. However, later losses or diseases such as joint ill were often linked to earlier events, which further blurred the boundaries. Some farm assurance schemes require farmers to record losses within defined periods (e.g. RSPCA requires the recording of calf losses from birth to 24 hours, 24 hours to 10 days and from 10 days to weaning), which were referred to by some interviewees, but were not always felt to represent the realities of early losses.

The lack of a clear definition of "neonatal losses", and conversely, what is defined as survival, is a potential barrier to recording relevant data and a challenge for the design and implementation of the Plan. As a result, the minimum data required for participation in the Plan is scanning percentages and weaning/sale numbers. This will ensure that the full spectrum of "losses" as defined by each individual vet or farmer is incorporated into the Plan. The majority of losses occur in the first week of life and so a benchmark for neonatal survival for the first 7 days of life may be a pragmatic solution to attempt to standardise the wide variety of definitions currently in use for the neonatal period.

> *"we do our benchmarking, a lot of the templates that we have they'll say death within 24 hours, and then it's 24 hours to seven days old, seven days old to weaning, and then weaning plus, but I would say the first three weeks are your babies… when it comes to filling in paperwork, that seems to be how it's separated."* (Vet A1)

Impact of losses

Understanding how losses affect farmers and their vets is central to understanding the drivers and barriers around minimising losses on farms. Vets and farmers described both the financial and emotional impact that they had experienced as a result of losses.

Financial

There is a clear financial cost associated with the death of lambs or calves resulting from both the loss of production and the costs of investigating and addressing the causes of loss. In general, calf losses have a greater individual cost (approx. £600-£800 for a weaned calf) due to the higher value of a calf in comparison to a lamb (approx. £65-£75). At a farm level, losses in sheep flocks were felt to result in higher overall losses, as a higher proportion of lambs do not survive. With sheep, a ewe who has lost her lamb(s) is still contributing to the flock, as she is likely to have multiple lambs or a triplet or orphan lamb can be fostered on to her, whereas a cow without a calf results more often in the loss of a whole production cycle. Live lambs and calves are the end product of sheep and suckler farms, and every loss has an impact on the farm's bottom line. Vets use the financial benefits of reduced losses as an incentive for farmers to take action and to demonstrate the value that can added by involving the vet.

> *"I've found that's the easiest way to get through to farmers is by essentially appealing to their wallet."* (Vet B1)

Emotional

While the financial aspect of losses is clearly important, the emotional impact of losses should not be underestimated. The farmers reported feelings of frustration, guilt, self-blame and depression in response to losses. From the earlier online survey results, it was found that many farmers are highly intrinsically motivated to maximise survival – in other words, they gain personal satisfaction from taking actions to reduce losses and achieving high levels of survival.

This may explain why losing lambs or calves is felt so acutely. Extrinsic motivators (i.e. the opinion of others) were also found to be relevant in the online survey, and farmers reported a stigma around discussing losses with their peers and a fear of negative judgement from others. Other farmers are an important source of information and support, and this peer network will not be available if the topic is not discussed.

> *"I just don't like losing things, and I take it really, really badly when I do, and it's not about money, it's more about you want everything to do as well as it can."* (Farmer A3)

> *"You think you should have done something, or could have done something, or what could you have done to stop that happening."* (Farmer C3)

> *"one of the problems I think that there is is that farmers don't talk. You're not going to say to people, by, we had 40 calves dead this year, you're not going to do that"* (Vet A1)

The veterinary participants experienced the emotional impact of losses themselves when assisting with a lambing or calving which did not result in a live birth, or when dealing with high levels of losses in a flock or herd. The vets reported that they had observed how their clients' wellbeing was affected by losses, and some had had to direct farmers towards other sources of support when they felt that their mental health had been affected.

> *"There are a few farmers that in the last 12 months I've had to sort of signpost to a few help organisations."* (Vet C1)

Improving the mental health of farmers and farm vets is an ongoing challenge for the farming and veterinary communities. This project has identified a potential relationship between neonatal survival and emotional wellbeing, however further work is required to understand how best to improve access to support for those who are affected e.g. via organisations such as You Are Not Alone (www.yanahelp.org) and the Farm Community Network (https://fcn.org.uk/).

<u>Perceptions of neonatal losses</u>

Tolerance for neonatal losses varies widely among farmers, and the level at which losses are perceived to be an issue is not consistent. Benchmarking figures were quoted by some participants, with losses above a certain percentage deemed unacceptable, but were often viewed with scepticism as not reflecting the individual circumstances of that flock or herd. Farmers with smaller numbers of animals pointed out that even a small number of absolute losses can result in a high proportion of losses. Some level of loss is accepted and normalised, particularly in sheep. The degree of acceptance of losses appears to be influenced by a range of factors, including the history of losses on the farm, the farmer's personality and motivation, the production system and the individual value of the lambs or calves. The cause of the losses also

has an effect; losses of individual animals due to circumstances considered to be unavoidable, such as accidents, were considered to be more acceptable than losses where farmers felt that they could have taken action to prevent or mitigate against the loss.

Perceived losses vs. actual losses

As demonstrated in Figure 10, farmer's perceptions of survival of their lambs are not consistently correlated with their actual level of loss. The Dunning-Kruger effect is a recognised psychological phenomenon, whereby people who are less competent often overestimate how well they are doing, and those who are more competent underestimate their success. The data from the online survey were not sufficient to explore whether a similar effect is present for calves, but from the interview data, it seems less likely. Farmers tend to know the exact number of losses with calves due to the lower numbers and higher individual value. In the absence of accurate data recording around lamb losses, farmers' perceptions are used as the measurement of the level of loss within the flock, which is a major barrier to identification of problem herds and effective intervention.

<u>Recording losses</u>

Data recording around neonatal calf losses was reported by the participants to be generally good, due to the requirement to record cattle births and deaths with the British Cattle Movement Service. In sheep flocks, record keeping varied among the farmers interviewed from no recording at all to very detailed electronic record keeping. Recording of losses is required by farm assurance schemes, although vets expressed doubts about the accuracy of the data recorded. The recording required of farmers, and particularly those with multiple enterprises such as livestock and arable, is extensive. Some degree of "recording fatigue" is perhaps therefore unsurprising. Practical challenges in data recording, such as taking notes in cold and dirty conditions while busy with other tasks, were acknowledged by participants, but some farmers do manage to have effective recording systems. Farms that don't perceive a problem with neonatal losses may not see the need to record.

> *"I've got a really well run farm, that is all outdoor lambing, New Zealand style system, and they lamb everything in late April, May, and they don't really record anything, but they're really on the ball with everything. But they wouldn't be able to tell you what their neonatal survival rate was."* (Vet A2)

> *"With the sort of things like Red Tractor Assurance and stuff like that… Most of them, they just make it up. They haven't a clue. It's a guess. How valuable that actually is for me and the farmer to share, it's hard to get them really engaged in it…"* (Vet D1)

Attempts by vets to encourage more farmers to start recording losses have been largely unsuccessful, despite efforts to overcome the practical barriers identified. Those who were

already recording viewed it as a valuable opportunity to learn and improve, while those who were not recording felt that it was depressing and frustrating. Avoiding the negative emotional impact of losses, as outlined above, was identified as the greatest barrier to recording lamb losses. By recording losses, farm staff are forced to face up to the associated negative emotions and stigma, as described above.

> *"…sometimes, that's a barrier to people, because if they start recording stuff, they're worried about whether they're actually doing awfully. They would be embarrassed by it…"* (Vet A2)

Given the substantial practical and psychological barriers identified to recording data around losses, farmers need to see a clear benefit. Those who do record tend to keep very detailed records about all aspects of their enterprise. These are used mainly to review the previous year's events, with a particular focus on breeding and culling decisions, and as part of the health planning process with their vet. The Plan requires very minimal data as an entry point, and can be used with only scanning and weaning/sale numbers. Interventions to reduce losses can be pinpointed more accurately by identifying the timing and cause of losses. Where a clear knowledge gap for their herd or flock can be identified by the farmer in the course of implementing the Plan, this may act as an incentive for more detailed recording in future.

<u>Farm management</u>

The foundation of neonatal survival, as identified by all interviewees, is ensuring that good basic husbandry is in place. These basics form the five pillars of the Plan: breeding, nutrition, colostrum, infection and shelter. Good management to avoid losses was described in the interviews as a process rather than a single event, which is reflected in the Plan's design with continuous involvement around the production cycle. The five pillars are interlinked throughout this cycle – for example, nutrition during pregnancy affects colostrum quality, which then influences susceptibility to infection.

> *"sometimes I think we get away from the basics too far and we've just got to go back to the basics"* (Farmer B3)

> *"nutrition, getting that right, hygiene and colostrum, if you get those three things right, I generally think most of it probably follows itself."* (Vet B2)

Colostrum

Colostrum was perhaps the most frequently mentioned topic around improving survival in the online survey and interviews, indicating that farmers are highly aware of its importance. Changing guidelines around the timing and volume of colostrum to be given were identified as a factor in reducing the trust of farmers in official advice. There was a perceived need for more

consistent, evidence-based guidelines. Practical challenges around providing colostrum include knowing whether a lamb or calf has received enough from the cow or ewe, knowing whether the quality is adequate, and the practicalities of collecting, storing and giving colostrum where intake is not sufficient, particularly in cattle. Some practical solutions described were using a halter to tie up ewes where the farmer finds it difficult to tip them up for health reasons, using a single milking machine on a large commercial suckler unit to collect colostrum from quiet cows, and assessing the suckle reflex of newborn calves as a proxy for colostrum intake. A number of commercial colostrum supplements are available, but not all are suitable for total replacement of natural colostrum, and vets were concerned that farmers may not use the appropriate product.

Nutrition

Nutrition was also identified by farmers as a key factor in neonatal survival and its importance throughout the whole production cycle, from mating to weaning, was described. Vets recognised that their expertise was primarily in disease control rather than nutrition, and were keen to work more closely with nutritionists.

> *"actually it would be nice if we had more interaction between the nutritionist, the vet and the farmer, and it would all work as one team… Such an important part of being a farm vet… if you chat to the nutrition guys, they love it if the vet turns up."* (Vet D1)

Shelter

The housing available at lambing and calving is a major challenge on many farms, particularly for tenant farmers who may not be able to invest in purpose-built facilities. Limited indoor space was one of the main issues for the participating farmers. This was managed in several ways: some restricted stock numbers to what they could house comfortably, while others rented or borrowed buildings when required, or moved animals outdoors as soon as possible once lambs and calves were suckling and bonded with their mothers. Some farms had outdoor pens that they used as a temporary area between lambing pens and turnout. One farm had invested in a system of plastic panels to build lambing pens and had found that these reduced the labour required at lambing time as they were lighter and therefore easier to move and to clean. They were also easily stored outside the lambing season. Shelter was an issue for outdoor systems and after turnout, particularly in cold and wet weather. Farmers using rented grazing were limited in the additional shelter that they could provide in exposed fields. Lamb jackets were used successfully on some farms to avoid losses due to exposure.

> *"we've got rubbish sheds, and we can't put any sheds of our own up because it's rented"* (Farmer A3)

Infection

The "infection" theme captures the measures taken to promote the health of the herd of flock, such as preventive treatments, vaccination, biosecurity and good hygiene. Good hygiene and regular cleaning of the housing was mentioned almost as frequently as colostrum. Dipping navels was also widespread in indoor systems. Antibiotic use is one of the most topical issues for livestock farming at present, and was therefore explored in more depth in the interviews.

Oral antibiotics are used to treat bacterial gastrointestinal infections ("watery mouth") in lambs. On some farms, oral antibiotics are routinely given to all lambs at birth. Oral antibiotics in this scenario are perceived to limit the risk of lamb losses and create a sense of reassurance for farmers. Historically, this has been perceived by some farmers to be best practice i.e. doing the best for the lambs to prevent disease, however industry best practice is clear that this represents inappropriate use of antibiotics. It is worth noting that oral antibiotics are considered by some to be a low cost solution, particularly when compared to the potential loss of a lamb. Routine prophylactic antibiotic use was less common in cattle in the experience of the participants. Antibiotics are used in some flocks as a mitigation strategy when other aspects of husbandry are not ideal, and in some situations, are perceived to be necessary to prevent widespread losses.

> *"we usually try and wait until we get a case or two before we do it, but as soon as I get a couple of cases, I'm kicking myself. I hate losing a fit, healthy animal, for, what I think, is something that's preventable."* (Farmer D1)
>
> *"In some situations where hygiene's atrocious, and colostrum quality is poor, and feeding's not right, then it probably does have a place…"* (Vet A2)
>
> *"Something like Spectam, I think it works out at 17p a lamb, if they don't do that, it could cost them potentially £70 a lamb if the lambs die, so it was a massive risk to them."* (Vet C2)

Vets are now working with their clients to encourage a shift away from routine prophylactic antibiotic use, with mixed success. The participants in this study felt that the drive for refinement in antibiotic use comes primarily from vets, although the farmers are also aware of the pressure to reduce use. Vets are well aware of the risks of antibiotic resistance and are working to reduce inappropriate use in neonatal lambs, with some having experienced clinical resistance in their own and their clients' flocks. However, this places the vet in a gatekeeper role, which may damage the supportive relationship that they attempt to build and maintain with each client. There is also a risk involved when routine prophylactic antibiotic use is withdrawn that disease and losses will increase, as some of the farmers had experienced. Some farmers have refined their antibiotic use with no ill effects, but others described increased disease and losses. This highlights the importance in addressing the underlying drivers of neonatal infections and the need to appropriately target antibiotic use. One vet has started providing farmers with probiotic

paste to be given orally in place of antibiotics, and used a smoking cessation analogy to describe this process. Several vets were aware when advising reductions in antibiotic use, that any potential negative impact for the farmer would be much greater than for them.

> *"I think it's a lot like smokers, you've got to replace their fixation with something, you've got to give them something else to put in their hand. So quite often probiotic pastes to make them feel like they're doing something"* (Vet B1)

Breeding

Breeding decisions are very much an individual choice on each farm and are driven by the goals for the business. Overall, the importance of breeding for easy lambing/calving, mothering ability and lamb/calf vigour was emphasised by farmers. Record keeping, as discussed previously, is used to inform breeding decisions and careful breeding decisions can reduce the need for labour on the farm at lambing and calving.

> *"Labour is expensive, so if you can breed it into them to do the job it reduces the labour… it is mainly focused on the female and making it as easy as possible for the calf or the lamb to suckle from her"* (Farmer C2)

> *"I've deliberately bred them for temperament and ease of calving. That comes before anything else."* (Farmer D1)

Staff

The farm staff are the key to ensuring good management is in place and that losses are minimised, and staffing is therefore a central component of the Plan. "Stockmanship" was a theme that emerged from the earlier analysis of the online survey data, and appeared again throughout the interviews. It described the attitude and values that underpin best practice when working with livestock, comprising keen observation and an ongoing desire to do the best possible for the animals.

> *"You're always thinking in your head what can I do to help it. If it's cold or whatever or what can I do to warm it up. Or if it has watery mouth, well, what can I give it now...?*" (Farmer C1)

Staff shortages are identified as a major barrier to implementing best practices and increasing survival. Some farms restrict animal numbers to what they can manage with available staff, but others need to carry higher numbers to make their business viable. Many of the farmers interviewed have minimal outside help with their breeding cattle and sheep - all the work is done by themselves and their immediate family. The intensity and increased workload of the lambing and calving period takes a toll on the staff, with lack of sleep and stress widespread,

exacerbating the emotional impact of losses. Health and safety is a consideration with farms aiming to have two people present for calvings.

Despite the acceptance of the heavy workload, there is a need to prioritise self-care around lambing and calving time, and to have a contingency plan in place in case of accident or illness of the key staff members. Family members with jobs off the farm may take annual leave around lambing time to help out when the need for extra labour is greatest. Temporary staff are also taken on for lambing and calving, including veterinary students on placements. The level of experience and engagement of staff can vary, but their attitude towards the animals is considered to be most important. Where possible, less skilled tasks such as cleaning out pens can be delegated to temporary staff, giving the farmer more time to provide skilled assistance where needed and manage the staff. Clear instructions – written where possible – for all temporary staff are valuable, as even experienced workers may not be familiar with the system on the farm.

> *"in the lambing, treat the staff as you would want to be treated yourself, 'cause if you've got a happy staff in the shed, they do a better job."* (Farmer D1)
>
> *" when you're short staffed it's alright saying they should have x amount of colostrum"* (Farmer A3)
>
> *"You might be absolutely cream crackered over three months and look like a zombie but that's the way it goes" (Farmer B2)*
>
> *"I went to do a Caesar for someone last year and she was coughing up a lung, and I was like, you need to go to the doctors, she said, I haven't got time."* (Vet D2)

Technology

Among the farmers interviewed, several were using new technology to assist with their workload and to make the best use of the labour available. This was more common among farmers with cattle, and particularly those with pedigree animals. Several farmers had installed CCTV in calving pens, which allowed them to monitor calving cows remotely. The advantages are that they can get on with other jobs or stay indoors while still watching the cow on their phone or television. They also reported that it avoided disturbing calving cows by going to check on them in person. Some had also used calving monitors worn on the cows tail to detect when calving was imminent and had found those useful. The costs were offset by even a relatively minor reduction in mortality. One farmer used an EID reader to record data on his sheep and found this very useful, although it became challenging if it wasn't working. A milk machine for feeding orphaned lambs was also beneficial on another farm. There was some scepticism about the

extent to which technology could help to reduce losses, indicating a need for more information about what is available and how it can help.

> *"for what they cost to buy and then the subscription for your software every year, you only have to lose one calf, half a calf, and it's paid for that"* (Farmer A2)

> *"we couldn't really manage without [the CCTV]"* (Farmer B3)

> *"I've almost become a bit too reliant on the reader and… if there is a problem, I get quite stressed and I need to use it."* (Farmer C1)

> *"I can't see how you'd lamb sheep with technology. You know, you've got to be there to see it."* (Farmer A3)

Vet's role

Veterinary support is an essential part of maximising survival, and three main areas of veterinary involvement around neonatal losses were identified from the interviews:

1. Reactive services for individual animals:

The traditional role of the farm vet, and the one that often came to mind first for the participating farmers, is responding to calls to deal with obstetric emergencies or sick animals. The question of when to call the vet to a lambing or calving was raised by both vets and farmers, with vets describing situations where they may have had a better outcome if they had been involved earlier. The farmers faced a judgement call between involving the vet when needed and avoiding the additional cost of unnecessary veterinary intervention. The value of the individual animal will influence their decision, with a greater willingness to call the vet early to a pedigree animal or a cow calving than to a lambing.

> *"But that's why, as I say, I get a vet, because if I do it, I'm always wondering if I've made a mistake, if we calf it and we lose it. If the vet calves it and loses it, well it wasn't my mistake, I'm not saying it's the right…but you know what I mean? I know I've done everything I can."* (Farmer D1)

2. Reactive services at the herd or flock level:

If the level of losses is deemed to be unacceptable, the farm vet is generally the first port of call. The point at which the vet becomes involved depends on each farmer's tolerance of losses, as described previously. The stigma and fear of judgement around losses also extends to the relationship with the vet. One vet was called out by a farmer who was losing a lot of lambs, but found him unwilling to admit to there being a problem when she arrived. Another recent graduate

found that farmers were sometimes reluctant to discuss losses, but would do so with a more senior vet where a trusting relationship had been established over a number of years.

> *"you get there and you're like, how many have you lost? 'Oh, well, we don't want to think about that,' and you're like, but you've lost a lot because you rang me"* (Vet A1)

> *"I would say it's sometimes hard to really understand what the numbers are because clients are not… they don't like to see it as a problem. So sometimes even with us, even as their, we hope, a trusted source of independent advice for a farmer, that there still seems to be a reluctance to always talk it through."* (Vet D1)

> *"I'm not aware of any other ones that were particularly losing, but then I probably wasn't the person they were going to speak to about that anyway."* (Vet D2)

The vets described the process of investigating losses in the herd or flock and emphasised the importance of going to the farm in person to understand the situation fully. Observing the farm environment and husbandry practices is an essential step to address problem losses. Diagnostic tests and post-mortem investigations were important tools to identify the cause of losses. The difficulty of reporting negative test results was described, as farmers often felt that the test has then been unnecessary, when in fact it had provided valuable information by ruling out an infectious disease.

A sudden increase in losses at lambing or calving can be difficult to resolve immediately. In some cases the problem is due to something that happened months ago, such as nutritional issues during pregnancy or the use of a bull with poor calving ease. Practically, both vets and farmers are busy and exhausted in the main lambing and calving period, and may not have the capacity to make major changes. Vets will investigate and do what they can to manage losses in the short term, but then plan a review meeting later in the year to discuss what happened and ensure that the same problem doesn't occur next year. The vets' approach to discussing neonatal losses is crucial, and must recognise that this is a sensitive topic. The importance of a supportive, non-judgemental attitude was emphasised.

> *"the culture that we have at this practice is a very healthy one in the sense of we are like working together, it's not we're dictating to them and they're not listening or they're saying they know better than us, it is a two-way street which I think is how it ought to be."* (Vet A1)

3. Preventive services, such as herd or flock health planning.

Vets are an important source of general information around neonatal survival for farmers. Practice meetings and newsletters are used to share information with clients. One practice had

held a meeting on neonatal losses recently which was well attended and received by the farmers who attended. Many of the attendees said that they had learned something new, as despite many years of experience, they had only seen how things were done on their own farm. Health planning for individual farms is an important tool to avoid health issues within the herd or flock. The Plan is designed to fit with existing health planning arrangements and support vets and farmers to maximise survival. The timing of health planning meetings, particularly for sheep flocks, varied between vets. Some like to hold a review in late winter, just before lambing, while others find that a conversation in the autumn before breeding works well. The Plan is designed for use at any stage of the production cycle, and aims to encourage ongoing dialogue between vets and farmers.

Several vets spoke of a lack of confidence around providing advisory services. These were generally young vets who had graduated recently, or those who were new to the practice. One recent graduate described how the more senior vets had their own farms, where they were the farm vet and knew the system well. She hoped to have more of her own farms as she gained experience. Until then, her main role on the farms was to deal with obstetric emergencies or sick animals. She was also involved in collecting samples to investigate losses, but the investigation was led by a more experienced vet. The younger vets interviewed were positive about a Plan as a valuable resource to provide evidence-based information to clients and support discussions around neonatal survival. More experienced vets were confident in their ability to have these discussion, but still felt that the Plan would be a useful tool to ensure that all of the relevant topics were covered.

> *"if I'm wrong, it's not my farm at stake"* (Vet C1)

> *"You know it all but actually having that written thing in front of you to tick…you tick the box or write a comment is really useful because you can't carry everything around"* (Vet C2)

> *"It's hard when you're in the moment to remember that the rest of the year happens."* (Vet C2)

An integrated plan to improve survival

To conclude the interviews, each participant was asked for their views on the development of an integrated plan to improve survival and were asked to describe the content and format that would be most useful to them. In terms of the content, there was agreement that it needed to emphasise the importance of getting the basics right without over-simplifying the information, and that it must be possible to adapt the content to meet the individual needs of each farmer. The five-point plan for tackling lameness in sheep was cited as an example of a useful resource. The five pillars of the proposed integrated plan – breeding, nutrition, shelter, colostrum and

infection – are based on the priorities identified from the interviews and the most important areas from the scientific evidence base. While vets agreed on the importance of an evidence-based approach, they wanted the information summarised and presented for practical application rather than having to work with multiple scientific papers. The main comment on the format of the plan was that it should be simple and visual without a lot of detailed text to be read. Opinion was divided on whether the Plan would be more useful in a paper or electronic format, with several interviewees suggesting that it would be helpful to have both options available.

> *"They just want simple, fairly simple, almost diagrams, is fine. It's what I like, a picture with this, this and this, it makes somebody look at it rather than a research paper."* (Vet B2)

Biological determinants of lamb survival and passive transfer in lambs

Whilst there has been a significant amount of work to better understand passive transfer status (i.e. colostrum antibody absorption) in calves, there is a relatively limited amount of similar work in lambs. This part of the project therefore sought to determine the relationships between ewe metabolic status and passive transfer status, and lamb survival, disease and performance (i.e. growth rate). The routine use of antibiotics at birth was also explored, by randomising oral antibiotic treatment to lambs at birth. Due to the difficulties of blood sampling large numbers of ewes and lambs on commercial farms, this work was undertaken at the University of Edinburgh's teaching flock.

All the ewes and lambs in a lowland lambing Scottish mule flock were blood sampled to determine the relationship between ewe metabolic status, lamb passive transfer (immune) status and lamb outcomes. In total, 252 ewes were sampled, with 236 ewes included in the study. Eleven ewes were excluded because ewes didn't produce any lambs (n=5), the lambs were not weighed within 24 hours of birth (n=9) or reared triplets (standard practice in this flock was to artificially rear all triplet lambs) throughout the study period (n=2). The ewe cohort sampled is described in Table 6. Of the 471 lambs born to 236 ewes, 38 were singles, 322 were twins and 111 were triplets. Between scanning and 24 hours post-partum, 0.0%, 9.5% and 37.0% of single, twin and triplet bearing ewes had a conceptus die (Figure 16).

Age	< 24 months	87
	36 months	58
	48 months	53
	48< months	38
Body condition	2	31
	3	111
	4	94
Ewes by number of lambs scanned	Single	29
	Twin	157
	Triplet	50
Ewes by number of lambs born	Single	38
	Twin	161
	Triplet	37

Table 6: Ewe descriptive data (n=236)

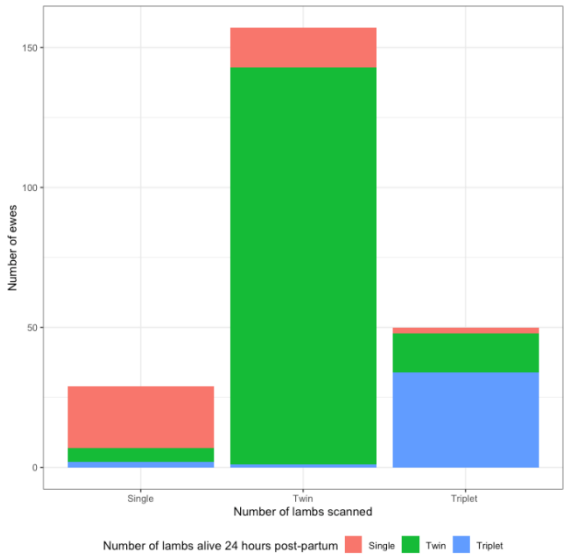

Figure 16: Number of lambs at scanning compared to 24 hours old (n=236). Number of lambs at scanning on x axis and colour represents the total number of lambs born surviving at 24 hours old. Colour of bar sections represents the number of lambs born per ewe.

Metabolic parameters

Ewe metabolic profile parameters are presented in Figure 17, aggregated by litter size (n=231, as 5 ewes did not have a metabolic profile completed). Few ewes had excessive beta-hydroxybutyrate and low urea-nitrogen, highlighting adequate short-term energy and protein requirements in all groups. Globulin results were generally lower than baseline, indicating low levels of inflammatory disease in the whole cohort. Albumin levels were distributed above and below the baseline for particularly twin and triplet ewes. Triplets and singles had significantly lower albumin than twins ($p<0.05$). However, there was no relationship between albumin and total litter birth weight (Figure 18).

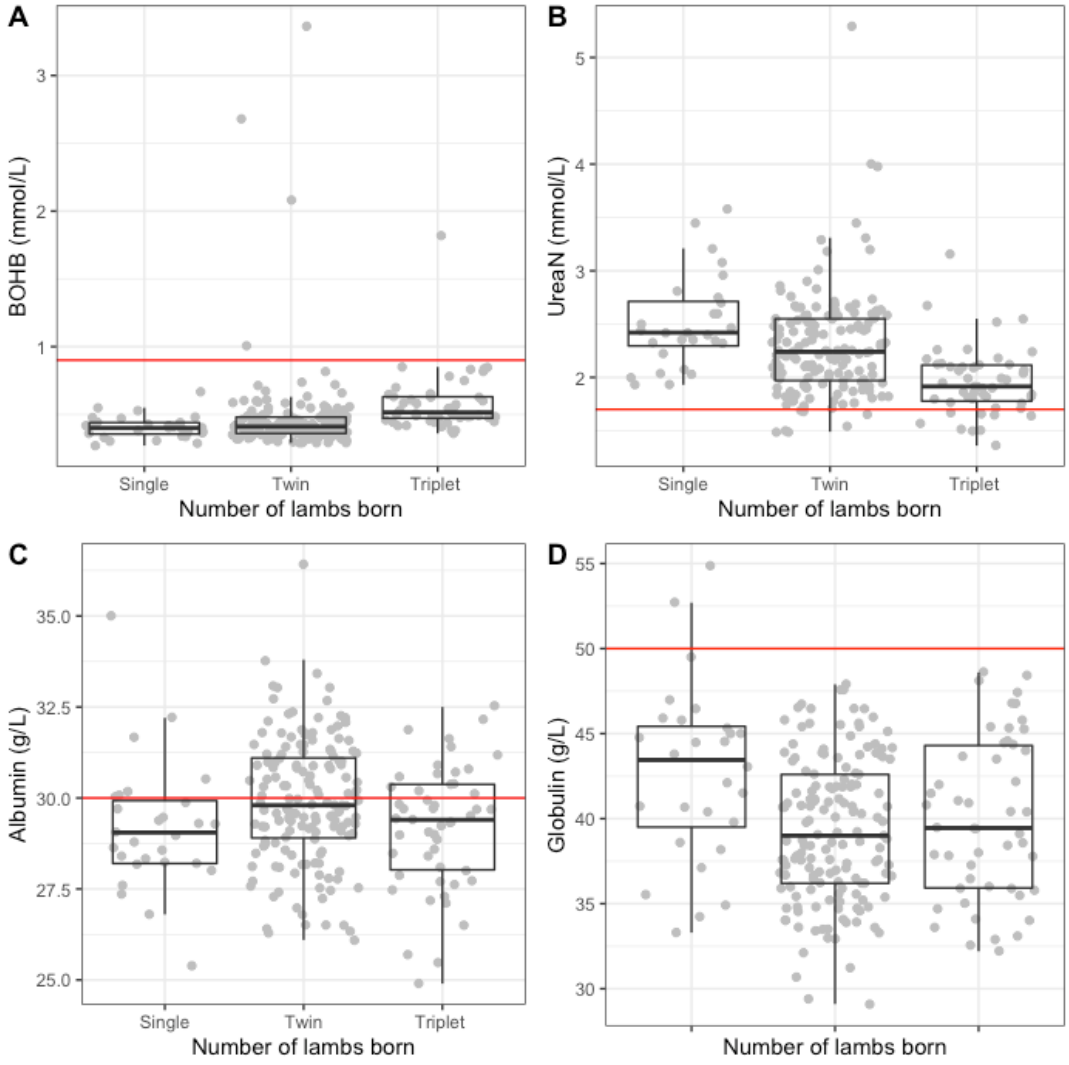

Figure 17: Ewe cohort serum metabolic profile (n=231). Baseline values are highlighted by the red horizontal line. A. Beta-hydroxybutyrate (BOHB); B. Urea nitrogen (Urea-N); C. Albumin; D. Globulin.

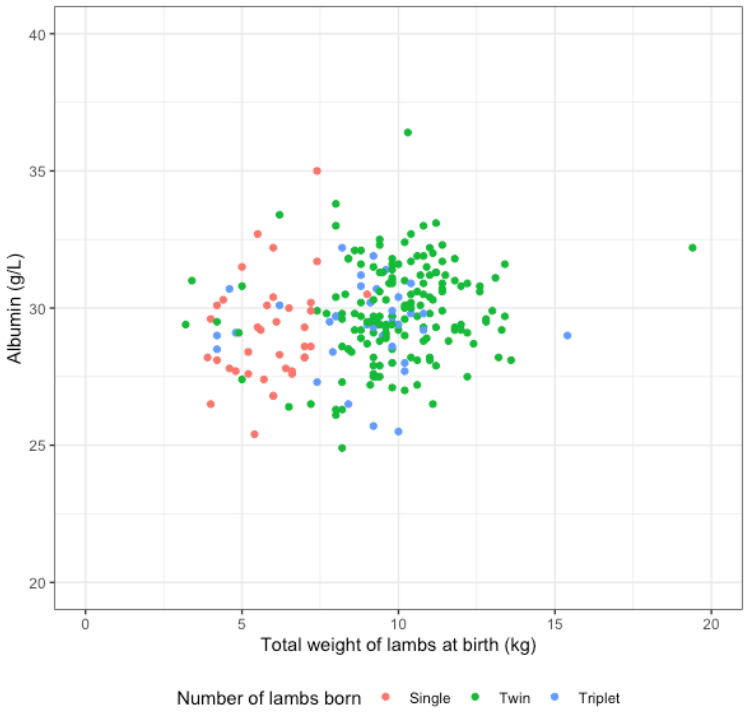

Figure 18. Relationship between ewe albumin and total weight of lambs born (n=231). Colour of points represents the number of lambs born per ewe.

Lamb details

In total 413 lambs born from 231 ewes were included and described in Table 7. Most lambs were born as twins and split evenly by sex. For birth weight male lambs were heavier than females ($p<0.01$). Singles were heavier than twins and triplets ($p<0.01$). Twins were heavier than triplets ($p<0.01$) (Figure 19).

Sex	Male	201
	Female	212
Sibling (born as)	Single	37
	Twin	306
	Triplet	70
Birth weight (mean and range)	Male	5.3kg (3.2-9.0kg)
	Female	4.9kg (3.2-7.6kg)
	Single	5.9kg (3.9-9.0kg)
	Twin	5.1kg (3.2-8.2kg)
	Triplet	4.7kg (3.2-6.4kg)

Table 7: Lamb descriptive data (n=413).

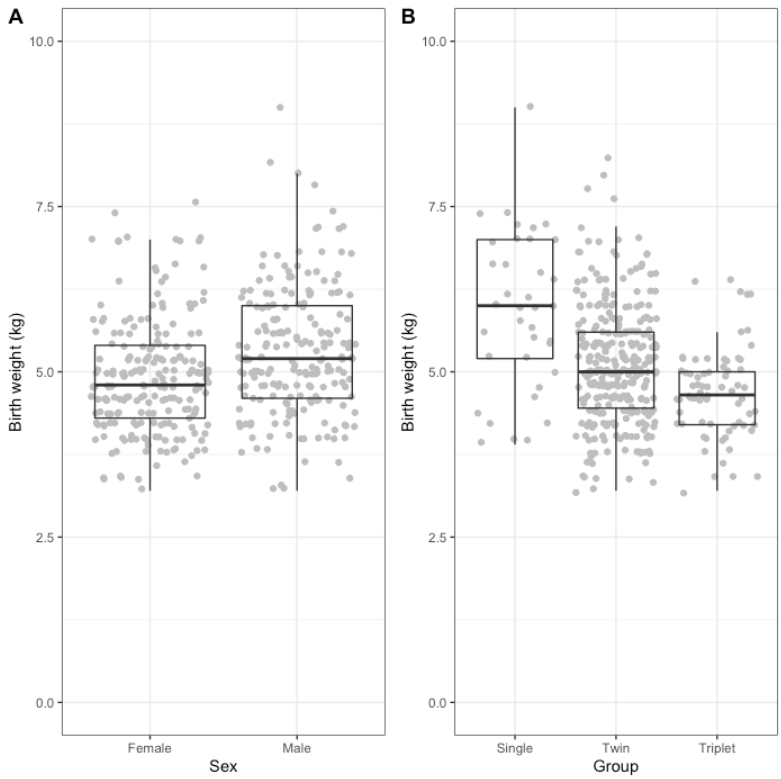

Figure 19: Lamb birth weight (n=413). A. by sex and B by litter size.

Prior to turn out, 15.7% of lambs were given additional colostrum (65/413). From birth through to weaning 4.1% of lambs died (17/413) and 2.6% were reported to suffer from an episode of clinical disease (11/413) that required treatment. Most reported causes of disease were watery mouth, joint ill and pneumonia. A total of 396 lambs were recorded at weaning.

Lamb birth weights ranged between 3.20-9.00kg (n=413) and weaning weights 19.50-53.00kg (n=396). Mean lamb daily live weight gain (DLWG) of 0.30kg was higher than the industry average for the top third of lowland farmers. When lambs were ordered by DLWG, the bottom third mean (0.26 kg) was nearly 0.1 kg lower than the top (0.35 kg) third mean (Figure 20; n=396). Although this was still higher than industry averages.

Immunological parameters

Serum IgG was measured in lambs between 8-24 hours post-partum (median= 31.66 mg/ml, IQR 19.71-44.53 mg/ml). Variation in serum IgG was noted in individual lambs with different numbers of siblings and throughout the lambing period (Figures 21 and 22). To the authors' knowledge, there are no published serum IgG values defining failure of passive transfer (FPT) in lambs. To define FPT, published IgG cut off values were used from dairy (≤10mg/ml) and beef calves (≤24mg/ml). Using these cut off values, 10.4% (43/413) and 33.2% (137/413) of lambs were suspected to have FPT respectively.

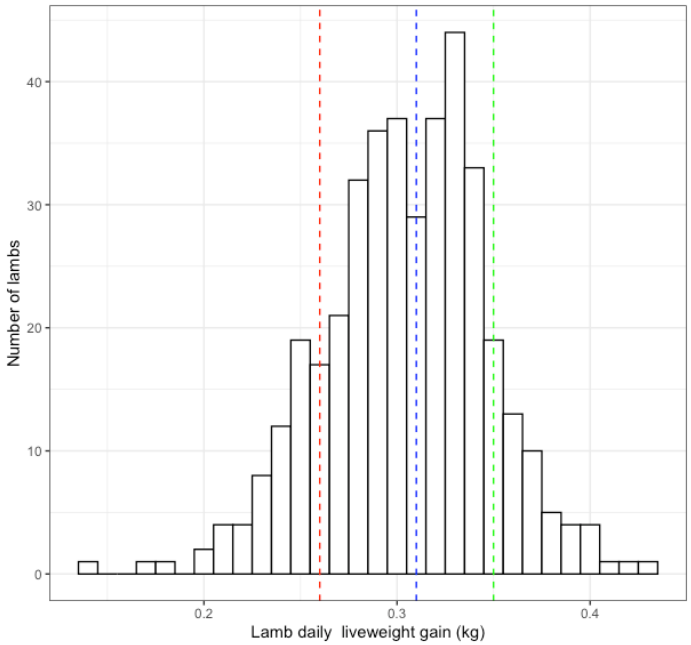

Figure 20: Lamb daily liveweight gain (DLWG). Dotted red line indicates mean of bottom third of lambs, blue middle third and green top third of lambs by DLWG (n=396).

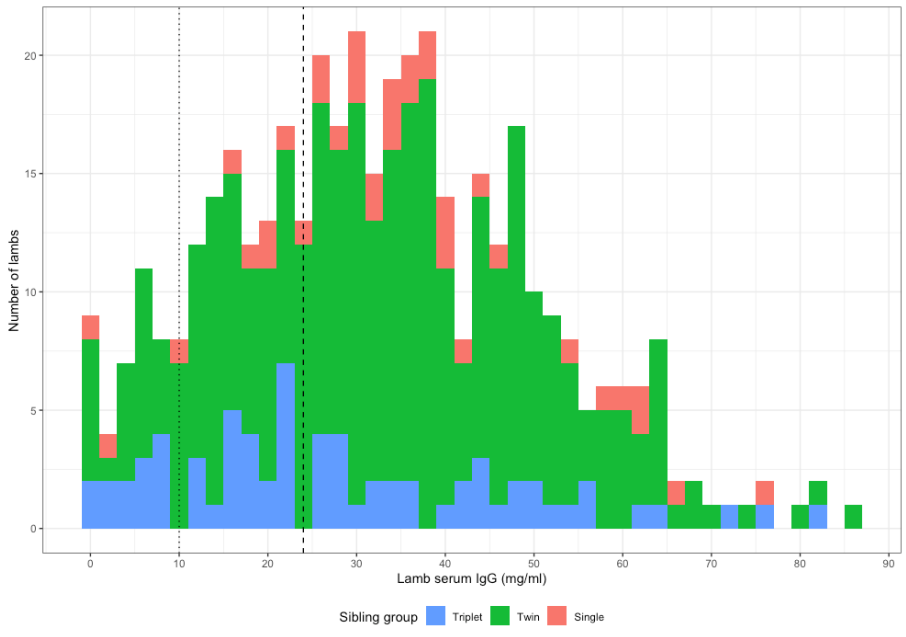

Figure 21: Lamb serum IgG distribution from lambs sampled (n=413). Each bar represent 2mg/ml. Colour of bars represents the number of siblings. Horizontal lines represent possible cut off values for failure of passive transfer: dotted line= serum IgG ≤10mg/ml ; dashed line= serum IgG ≤24mg/ml.

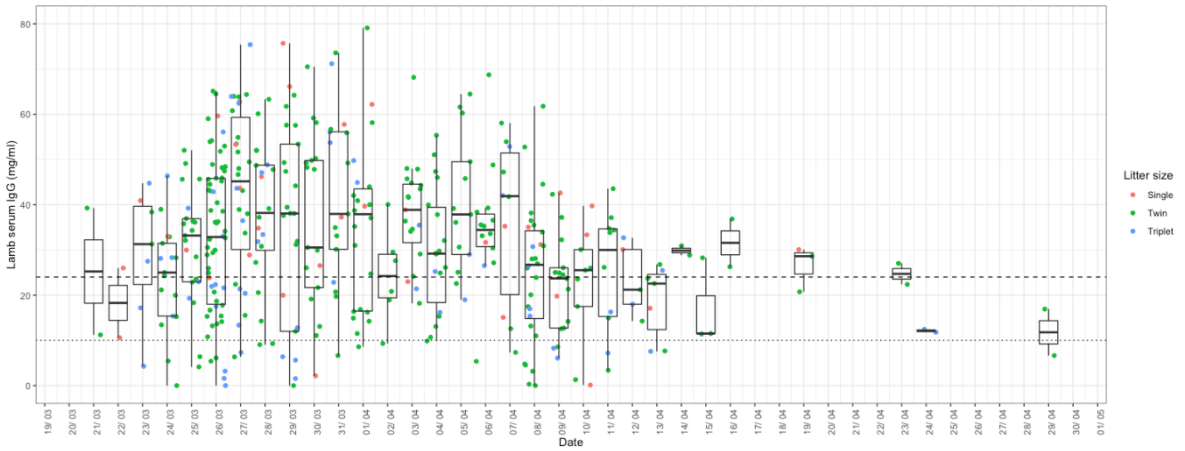

Figure 22: Lamb serum IgG distribution throughout the lambing period (n=413). Colour of points represents litter size. Horizontal lines represent possible cut off values for failure of passive transfer: dotted line= serum IgG ≤10mg/ml; dashed line= serum IgG ≤24mg/ml.

Factors associated with losing a lamb between scanning and 24 hours post-partum

Of ewes with complete metabolic profile results (n=231), 0% (0/28) single, 9.2% (14/153) twin and 32.0% (16/50) triplet bearing ewes lost a lamb between scanning and 24 hours post-partum. As no losses were reported in ewes with single lambs, only ewes scanned with twins or triplets were included for further analysis (n=203). Univariable analysis investigated relationships between intrinsic ewe and lamb factors potentially associated with losing a lamb. These included ewe age, body condition score, number of lambs scanned, total litter birth weight and metabolic profile parameters (BOHB, Urea-N, Albumin and Globulin). From univariable analysis, number of lambs scanned ($p<0.01$), total litter birth weight ($p<0.01$), ewe albumin ($p<0.01$) and globulin ($p<0.01$) were included in the final multivariable logistic regression (MLR) model. Total litter birth weight and globulin were removed from the model due to their biological relationship with number of lambs scanned and albumin values respectively. In the final model, ewes scanned with twins (OR=0.25, 0.00-0.12, $p<0.01$) and increased albumin (OR=0.76, 0.00-0.60, $p<0.05$) had decreased odds of losing a lamb (Table 8).

Factors associated with lamb serum IgG 8-24 hours post-partum

Association between intrinsic ewe and lamb factors with lamb serum IgG at 8-24 hours old were initially explored (n=413). Factors included lamb sample date, weight, sex, litter size, ewe age, body condition score, total litter birth weight and metabolic profile parameters (BOHB, Urea-N, Albumin and Globulin). As none of the variables demonstrated association with raw values, ≤10mg/ml and ≤24mg/ml serum IgG cut off values were used to explore potential relationship between FPT and ewe/ lamb intrinsic factors.

Model	lambs_lost~No..Lambs + Albumin *Binary outcome: Lost >=1 lamb*		
Variable	**Level**	**OR (95% CI)**	**P value**
Number of lambs at scan	Triplet	Base	
	Twin	0.25 (0.00-0.12)	<0.01
Albumin	*as numeric*	0.76 (0.00-0.60)	<0.05

Table 8: Final MLR model factors associated with ewes losing a lamb between scanning and 24hours post-partum (n=203).

Model	SRUCIgG_b10~ (1|EWE.ID) + lambs_tagged_cat *Binary outcome: serum IgG≤10mg/ml*		
Variable	**Level**	**OR (95% CI)**	**P value**
Litter size	Single	Base	
	Twins	1.29 (4.40-37.91)	0.51
	Triplets	3.52 (8.66-142.92)	0.88

Table 9: Final MLR model for factors associated with lamb serum IgG ≤10mg/ml (n=413). Including ewe as a random effect.

Model	SRUCIgG_b24~ (1|EWE.ID) + lambs_tagged_cat + BOHB *Binary outcome: serum IgG≤24mg/ml*		
Variable	**Level**	**OR (95% CI)**	**P value**
Litter size	Single	Base	
	Twins	1.31 (0.52-3.28)	0.56
	Triplets	2.98 (1.01-8.81)	<0.05
BOHB	*as numeric*	5.16 (1.44-18.39)	<0.05

Table 10: Final MLR model for factors associated with lamb serum IgG ≤24mg/ml (n=413). Including ewe as a random effect.

For ≤10mg/ml serum IgG, total number born ($p<0.05$) and ewe age ($p<0.1$) were identified as significant on univariate analysis. Only litter size remained in the final MLR model but was not significant (Table 9).

For ≤24mg/ml serum IgG, litter size($p<0.01$) and BOHB ($p<0.01$) were identified as significant on univariate analysis. In the final MLR model, triplet lambs (OR=2.98, 1.01-8.81, $p<0.05$) and lambs from ewes with increased BOHB (OR=5.16, 1.45-18.39, $p<0.05$) (Table 10).

Factors associated with lamb morbidity and mortality

Due to the small number of lambs which suffered from an episode of disease or death, we could not investigate potential risk factors associated with these outcomes.

Factors associated with lambs being given additional colostrum

As only one single lamb was given additional colostrum, further analysis was completed on a subset of twin lambs (n=360 lambs). The binary outcome was, “lamb given additional colostrum”. The lamb factors screened in univariable analyses were sex, passive transfer status (dairy or beef cut off, two separate analyses) and provision of oral antibiotic treatment. The ewe factors screened were pre-lambing metabolic profile results (BOHB, Urea-N, Albumin and Globulin), number of fetuses scanned, total litter birth weight, BCS, and ewe age. Lamb’s passive transfer status (dairy ($p<0.05$) and beef ($p<0.01$)), ewe BOHB ($p=0.10$) and albumin ($p<0.01$) levels and BCS ($p=0.14$) prior to lambing were carried forward to the maximal mixed effects multivariable logistic regression (MLR) model (Figure 23). In the final model included passive transfer status (beef) and ewe pre-lambing albumin status as fixed effects and ewe as a random effect. Those lambs defined to have failure of passive transfer (beef cut off value) had increased odds (OR=7.42, 1.25-43.91, $p<0.05$) of being given additional colostrum (Table 11).

Model	lamb_addcol_ever~ (1|EWE.ID) + beef + albumin *Binary outcome: DLWG<0.26kg per day.*		
Variable	**Level**	**OR (95% CI)**	**P value**
Passive transfer status (<24mg/ml)	Adequate	Base	
	Failure	7.42 (1.25-43.91)	<0.05
Albumin (g/L)	*as numeric*	0.79 (0.42-1.47)	0.45

Table 11: Final MLR model factors associated with giving additional colostrum to twin lambs (n=360).

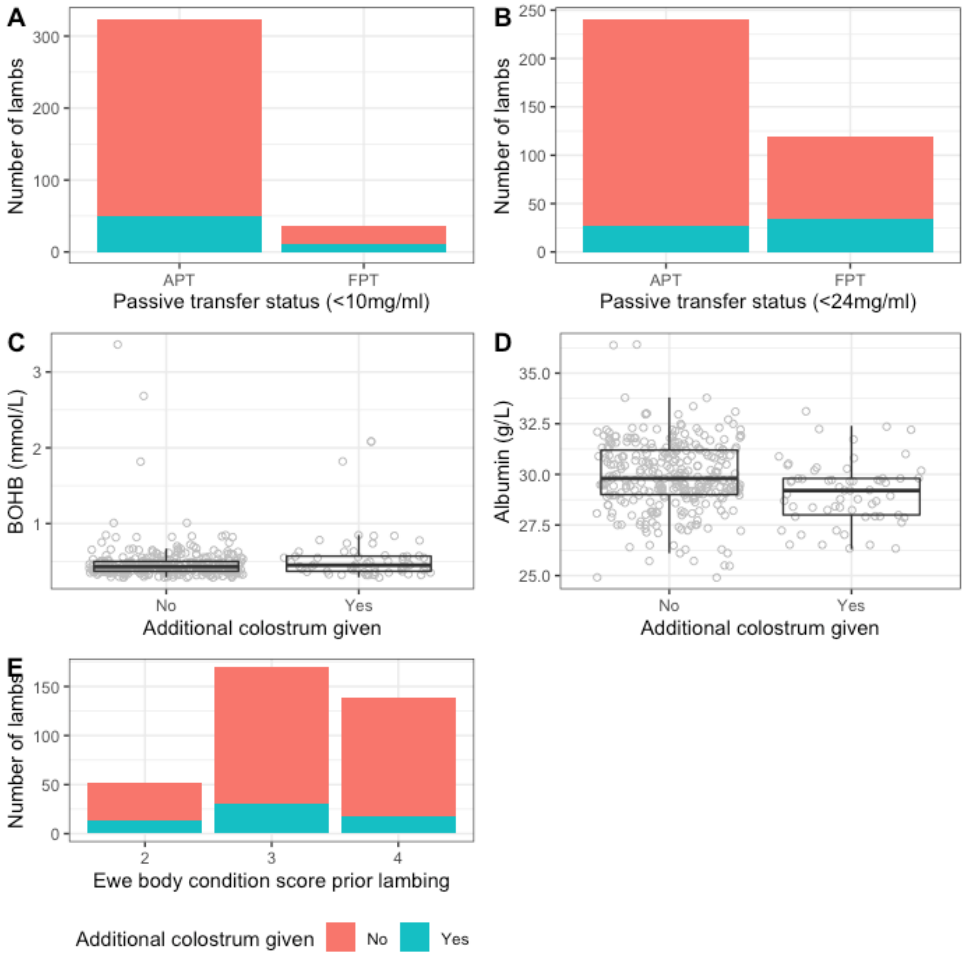

Figure 23: Significant relationships with twin lambs being given additional colostrum by A. passive transfer status (defined at <10mg/ml), B. passive transfer status (defined at <24mg/ml), C. ewe BOHB pre-lambing, D. ewe albumin pre-lambing and E. ewe body condition score (n=360).

Factors associated with lamb growth

Male lambs were born heavier than females ($p<0.01$) and those reared as singles were born heavier than those reared as twins ($p<0.01$) (Figure 24; n=413). At weaning, a similar pattern was noted when lambs were split by sex ($p<0.01$) and litter size ($p<0.01$) (Figure 25; n=396). There was no relationship between lambs with adequate passive transfer (dairy or beef cut off value), being given oral antibiotic (Figure 26) or additional colostrum and birth or weaning weight.

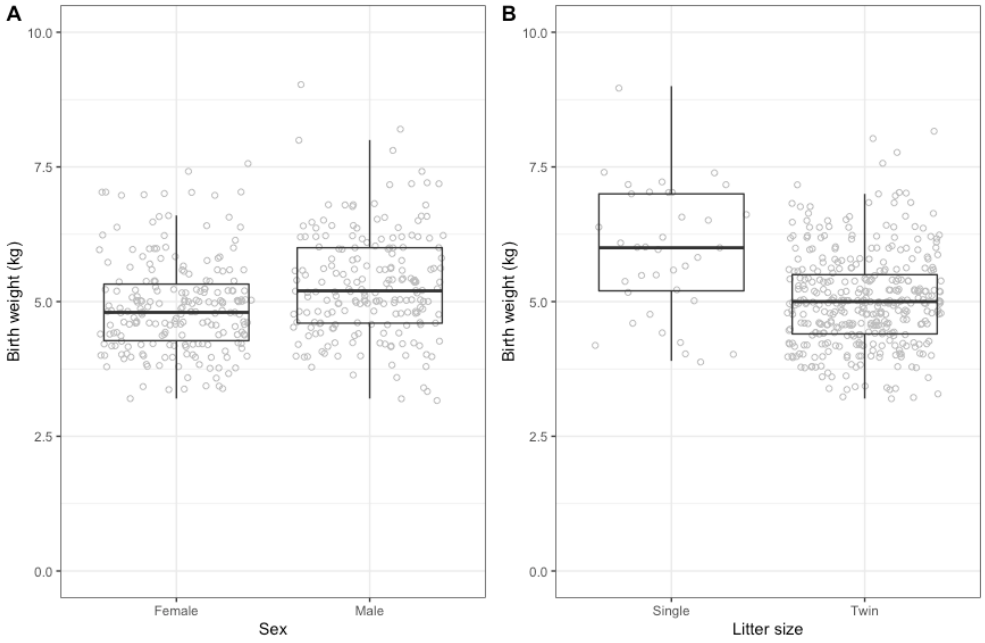

Figure 24: Lamb birth weight by A. sex and B. litter size (n=413).

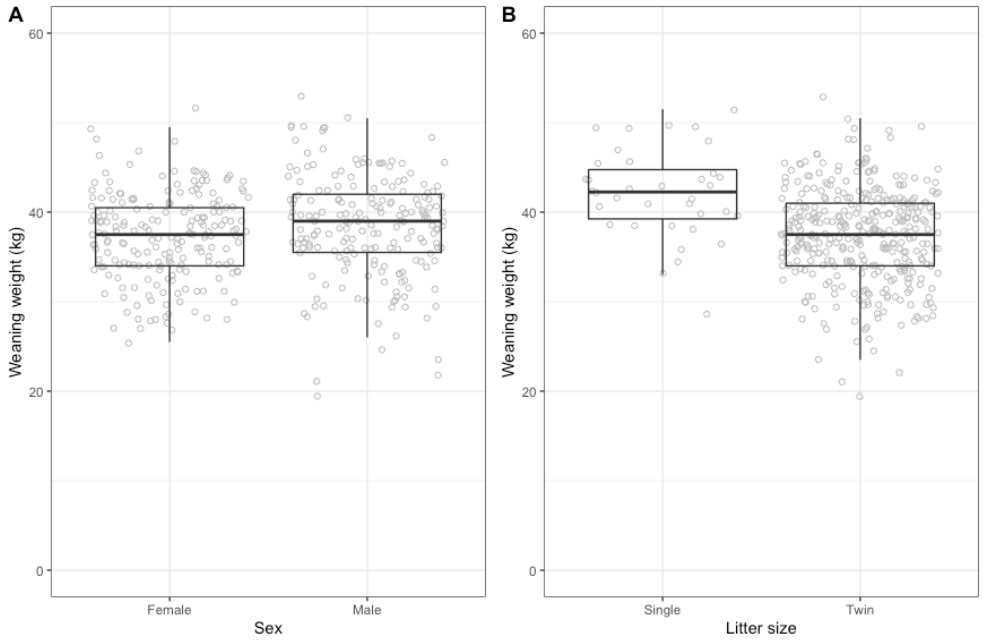

Figure 25: Lamb weaning weight by A. sex and B. litter size (n=396).

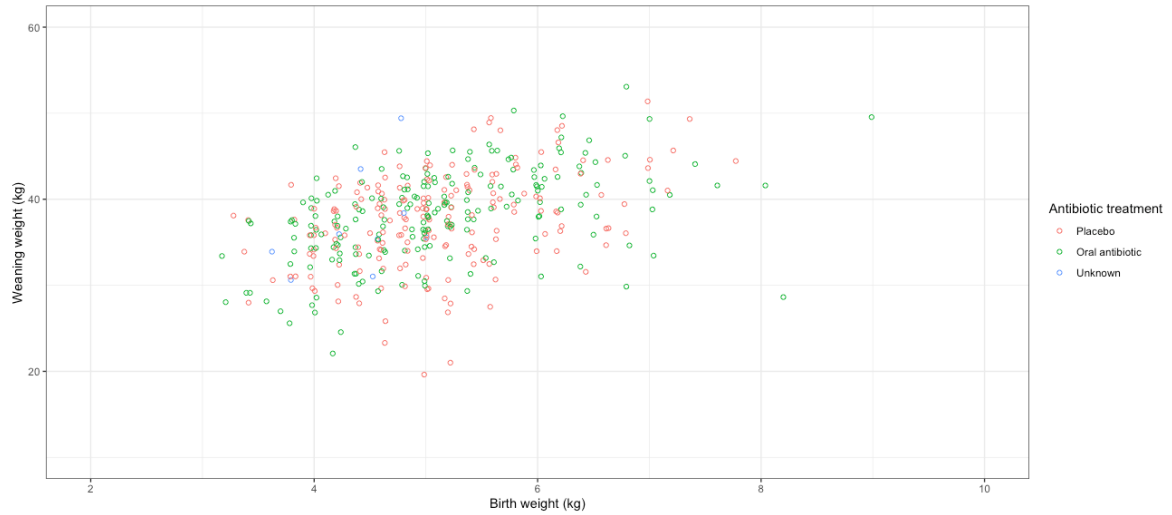

Figure 26: Relationship between lamb birth weight and weaning weights by oral antibiotic treatment (n=396).

A key finding here was the weak relationship between birth weight and weaning weight (Figure 26; r2= 0.19). Being born large did not predict being big at weaning. Therefore, we explored the factors that may have influenced lamb DLWG. Singles had a higher DLWG compared to twins ($p<0.01$). There was not a significant difference in daily liveweight gain between male and female lambs, or between those that were defined to have adequate passive transfer or not(dairy or beef cut off value), or those that had received additional colostrum, or oral antibiotic (Figure 27; n=396, $p>=0.05$). Ewe factors (nutritional status, BCS, age and scan result) also did not have a relationship with DLWG. Relationships did not alter when single lambs were removed from the dataset (n=360).

Due to the variation in lamb DLWG across the cohort, we investigated lamb and ewe factors that could be associated with reduced DLWG. “Reduced DLWG” was defined as “<0.26kg per day” as this was the mean DLWG for the bottom third of lambs. All lambs defined as having reduced DLWG were twins, consequently twins were subsetted for subsequent analysis (n=360). Univariate analysis explored the same lamb and ewe factors as previous with plus the additional colostrum variable. Lambs given additional colostrum ($p<0.01$), passive transfer status (dairy ($p<0.05$) and beef ($p<0.01$)), total litter weight at birth ($p<0.05$), ewe BOHB ($p<0.01$) and albumin ($p<0.01$) levels prior lambing were included in MLR model selection (Figure 28). In the final MLR model, additional colostrum and passive transfer status (beef) were included as fixed effects and ewe as a random effect. Twin lambs defined to have failure of passive transfer (beef cut off value) had increased odds (OR=4.75, 1.17-19.19, $p<0.05$) of having reduced DLWG (Table 12).

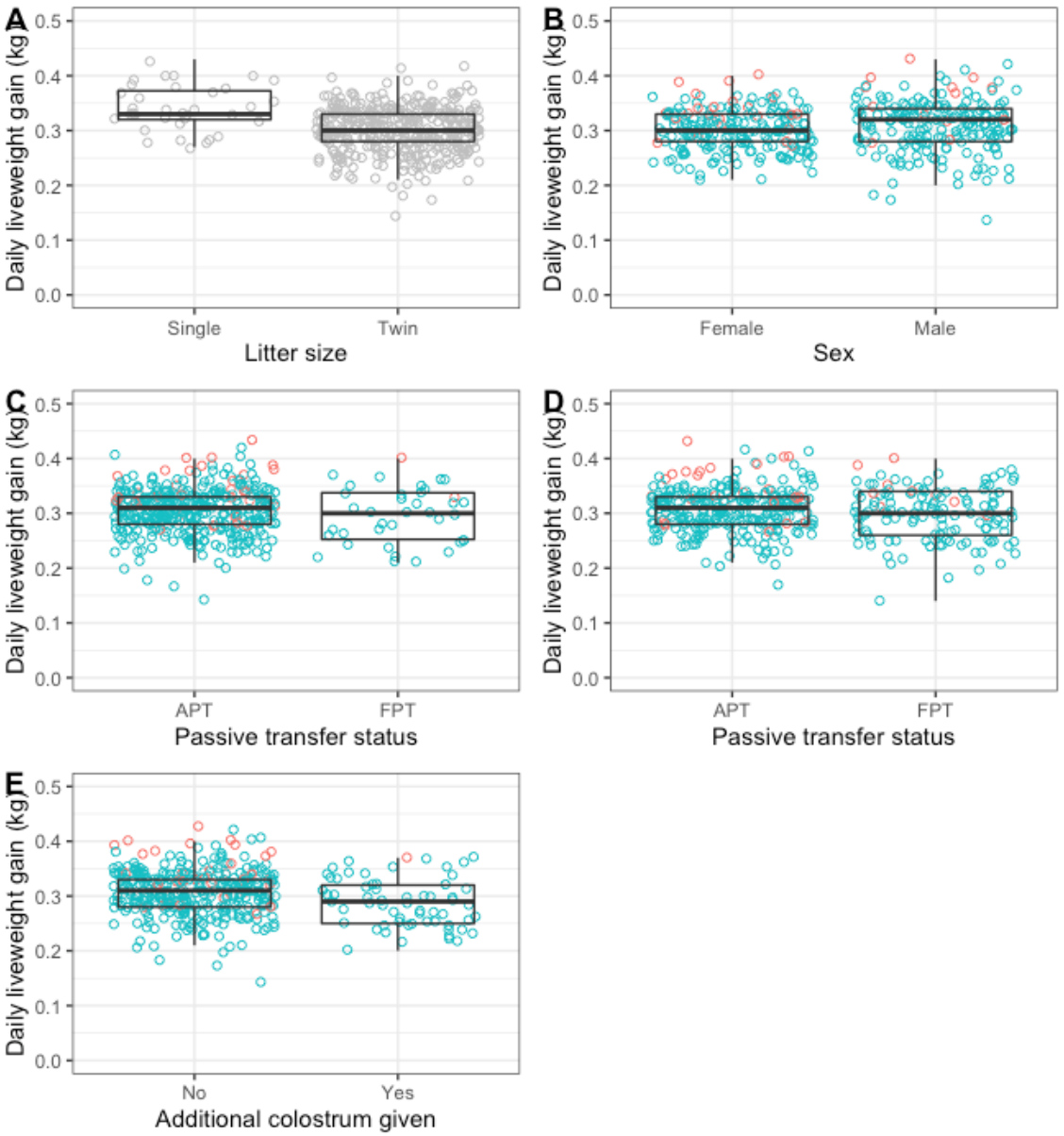

Figure 27: Lamb daily liveweight gain (DLWG) by A. litter size, B. sex, C. passive transfer status (defined at <10mg/ml), D. passive transfer status (defined at <24mg/ml) and E. whether additional colostrum had been given. Red dots = single lambs, blue dots= twin lambs (n=396).

Model	lowDLWG~ (1|EWE.ID) + lamb_addcol_ever + beef *Binary outcome: DLWG<0.26kg per day.*		
Variable	**Level**	**OR (95% CI)**	**P value**
Additional colostrum given	No	Base	
	Yes	3.79 (0.65-21.94)	0.14
Passive transfer status (<24mg/ml)	Adequate	Base	
	Failure	4.75 (1.17-19.19)	<0.05

Table 12: Final MLR model factors associated with <0.26kg DLWG in twin lambs (n=360).

Q4 Discussion: What do the results mean for levy payers?

Context

Estimates of neonatal suckler calf and lamb mortality are difficult to obtain, with few studies available in the peer reviewed literature. This study set out to determine the neonatal mortality rates reported by beef and sheep farmers across GB and to relate these to different husbandry practices, with data collected by veterinary surgeons and students from a small subset of respondents used to validate the mortality rates reported by farmers.

Challenges

Despite widespread promotion of the questionnaire by the levy boards in England (AHDB Beef and Lamb), Scotland (QMS) and Wales (HCC), only 71 beef and lamb levy payers completed the questionnaire. Whilst not all levy payers will have breeding herds and flocks, and some may not be able to access the internet, this disappointing response rate serves to illustrate the challenges in engaging with producers about neonatal mortality. Whilst survey fatigue and limited time availability are undoubtably challenges when reaching out to farmers, a detailed ethnographic study of farmer and vet attitudes was undertaken to explore attitudes towards neonatal mortality in more depth.

Attitudes towards neonatal survival

Neonatal losses are a concern for farmers, particularly due to the impact on their business, however farmers' belief in their ability to improve neonatal survival is variable – the majority of respondents felt that that they are able to improve neonatal survival through their actions, but some lacked confidence.

Current practices to improve neonatal survival are founded in a belief in good stockmanship and take place throughout the production cycle. Farmers generally take action to reduce neonatal losses because they want to, rather than because they feel that they have to due to external pressures.

Barriers to change

Both practical and cultural barriers to improving neonatal survival were identified in interviews undertaken with farmers and their vets. The main practical challenges were housing and shelter, particularly for tenant farmers, and staffing. The emotional discomfort and social stigma around neonatal losses are barriers to conceptualising, recording and discussing the issue, which limits the cultural and behavioural change needed to increase survival. In engaging with farmers, the potential for emotional discomfort and the sensitive nature of the topic of losses must be considered.

Enablers for change

Despite a number of barriers to change, there are also strong drivers for change and improvement. Farmers and their vets are highly motivated to reduce losses, and the financial and emotional benefits of increasing survival are well recognised by the study participants. While the farmers interviewed are likely to represent the more engaged, proactive clients of the veterinary practice by virtue of having agreed to take part in the project, they are already implementing a number of innovative and effective strategies to maximise survival.

Estimates of neonatal mortality

As a consequence of the poor online questionnaire response rate, risk factor data were only analysed for the 130 farms that were recruited via their veterinary surgeons or lambing student placements. This significantly reduced the power to associate management practices with neonatal mortality rates and also introduces additional bias into the original study design, with participating farms being those that are more likely to engage with veterinary surgeons or students. This is particularly evident in the population of suckler herds included in this study, which were predominantly from lowland areas. The high proportion of suckler farmers reporting the use of metabolic profiles for example also likely reflects a strong bias towards more proactive producers, as this is a relatively uncommon practice in GB suckler farming. This is less of a concern with respect to the sheep farms, where at least a quarter of the participants were from hill and upland areas. It was reassuring that the average size of participating farms was similar to the GB average.

The estimates of calf and lamb mortality rates on GB farms from this study provide a contemporaneous benchmark for suckler and sheep farmers. Whilst there were some extreme outliers, median mortality to 21 days of 4.4% in suckler calves and 8.2% in lambs is in keeping with historic data for sheep, indicating little improvement in performance over the past 20 years. The vast majority of losses in both calves and lambs occurred within the first 7 days of life (Table 1), hence whilst the definition of the neonatal period varies between studies, vets and farmers, it is clear that efforts to improve survival must focus on the events that lead up to and occur during the first week of life. The top quartiles of farms were able to achieve 21 day lamb mortality of 6% and calf mortality of 2.5%, which could form the basis of an achievable industry target. That said, the farmer interviews identified a desire to set farm-specific targets and so it may be more appropriate to show farm managers the distribution of mortality between farms and encourage them to select a target that is meaningful for their farm.

The observation that mortality rates do not vary by farm size, with many larger farms reporting mortality rates well below average (Figure 3) is particularly interesting, as it indicates that good processes on farms, regardless of size, can drive positive outcomes. This is particularly important given current trends towards larger farms and consumer concerns in relation to this.

Data recording

Perhaps the most significant finding from the questionnaire data is the lack of a correlation between farmer estimated mortality rates in 2018 and vet/vet student observed mortality rates in 2019 (Figure 8). A small number of farms reported congruence between the two measures, suggesting that these farms were accurately recording mortality and achieving consistent performance between years. Whilst all farms will periodically have a "bad year", the lack of a correlation between the two measures suggests that either performance is being inaccurately recorded by many farms and/or performance between years is highly inconsistent. Both present challenges to making improvements in neonatal survival. From the questionnaire responses in this study, it appears that most suckler farmers at least have access to reliable data, which would tend to support the suspicion that performance is highly variable between years. The same is not true of sheep farms, where nearly 2 in 5 respondents indicated that they made no record of mortality. Despite this, with the exception of the most confident farmers, sheep farmers' perception of neonatal mortality on their farm tended to improve as observed mortality rates improved (Figure 10). That said, farmers were asked to rate performance in their flock relative to "average" and the majority of sheep farmers who rated their performance as better than average, had performance that was in fact worse than the median 8.2% reported in this study, hence suggesting that farmers either have a poor appreciation of average performance or that they over estimate their own performance.

Taken together, these results indicate that low rates of neonatal mortality are achievable on both suckler beef and ewe lambing flocks of all sizes in GB. However, complex barriers to data recording and potentially variable performance between years are major obstacles to achieving consistent improvements, whilst farmers' perception of their own performance does not provide a reliable substitute. Whilst many data driven initiatives are now available to livestock farmers, until basic recording can be improved, there is limited scope to make progress in understanding the drivers of poor and/or inconsistent performance both within and between farms.

Risk factors for neonatal mortality

Despite the limited power of this study, there were some interesting trends in mortality across different husbandry and farm factors that are worthy of consideration. The slightly increased mortality in outdoor versus housed lambs is not surprising and is captured by the increased proportion of outdoor lambing farms recognising starvation, exposure and predation as causes of loss (Tables 3 and 4). Field shelters for lambing ewes have the potential to reduce these losses, but have largely been neglected and there is a need to better understand how different breeds, shelter designs and landscapes interact with lamb mortality. Whilst losses due to intervention at lambing were recognised as causes of death in lambs under 7 days old by an equal proportion of indoor and outdoor lambing flocks, it was interesting that joint ill was recognised by a greater proportion of outdoor lambing flocks in lambs over 21 days old. This

might indicate the impact of reduced supervision of young lambs, with cases not being picked up until they become a more chronic debilitation in older lambs.

Injuries at birth were recognised as a cause of death in calves under 7 days old by a much higher proportion of suckler farmers (52%) than sheep farmers (20-21%). It is unclear whether this represents a greater proportion of farms struggling with calving injuries compared to lambing injuries or more recognition of the impact of a difficult birth on calf survival than lamb survival. Bull selection can have a significant impact on calving difficulty, but fewer than half of respondents reported using calving ease estimated breeding values (EBV) in their choice of bull. Whilst there was no evidence in this study that bull breed had an impact on calf mortality rates, recent work has demonstrated increased rates of dystocia in Charolais compared to Aberdeen Angus sired calves. The results of this study therefore indicate that although calving injuries are recognised by over half of respondents as a cause of calf mortality, more work needs to be done to increase the use of EBVs in bull selection. This is despite concerted efforts to educate producers regarding the value of EBVs in recent years.

Colostrum is another area of neonatal management that has been a major focus of communication to farmers, including extensive industry led campaigns such as #ColostrumIsGold. Despite this, the vast majority of sheep and suckler farmers reported feeding significantly below the recommended volumes of colostrum when supplementing lambs and calves. This would align with recent data indicating that assistance with colostrum feeding represents a risk factor for failure of passive transfer in suckler calves and lambs (Table 11). Taken together, it appears that farmers are good at identifying those animals in need of supplementation, however inadequate amounts of colostrum are being provided. Suckler and sheep farmers are therefore devoting valuable time, and sometimes considerable expense when purchasing commercial colostrum substitutes, in an activity that is ineffective. This study provides further evidence that farm teams should check their colostrum supplementation protocols prior to the start of lambing and calving to ensure that adequate volumes of colostrum are being provided at an appropriate time.

Perinatal cow housing management has been highlighted as a possible source of variation in mortality, with some indication in this study that moving cows before calving and providing new straw only once cows look dirty has a weak association with increased calf mortality. Interestingly, moving cows prior to calving has been identified as a risk factor for neonatal mortality in work in Canada, whilst infrequent bedding with straw is a recognised risk factor for mastitis in dairy cows. Whilst further work is required to demonstrate that these can be reliably identified as risk factors, advising herds to ensure that cows are kept visibly clean and are not moved shortly before calving would seem sensible.

When considering supervision, there is good evidence that improved supervision can improve neonatal survival. In this study however, there was no relationship between neonatal mortality and the ratio of breeding females to staff FTEs, whilst no industry benchmarks exist for this ratio, which varies widely and is an important determinant of profitability. The implication is that neonatal survival cannot simply be improved by an increase in FTEs, but is related to the quality

of supervision. The increased calf mortality in herds that reported also having a lambing flock was of particular interest and potentially suggests that in these farms, supervision is prioritised for the sheep instead of the cattle. There was also no relationship between the length of the calving/lambing period and neonatal survival, again indicating that an intense lambing/calving period can be as successful with respect to neonatal survival as a longer period, provided that staff supervision and other factors such as hygiene are appropriately managed. Interestingly, herds that reported culling empty cows following pregnancy diagnosis tended to have lower calf mortality. Whether this represents a biological effect e.g. empty cows are more likely to be affected by an infectious disease that may affect neonatal mortality or is simply a correlate of some other herd management factors is unclear.

Unfortunately, the questionnaire did not identify conclusive novel risk factors for neonatal mortality, however it has highlighted a number of key areas where best practice is not being effectively deployed on commercial suckler and ewe lambing farms. It also highlights the need to assess potential risk factors at the farm level and tailor changes to management to the specific issues affecting an individual farm. The fact that large farms with high ratios of breeding females to FTEs can achieve low levels of neonatal mortality indicates that more efficient production systems with respect to labour and capital allocation do not necessarily result in greater wastage and animal suffering with respect to neonatal mortality. Significant effort (daily student and weekly veterinary surgeon recording) was required to overcome the barriers to obtaining accurate records of neonatal mortality, highlighting the need to address the behavioural barriers to improved recording and the obstacle this poses to making further progress in improving neonatal survival.

<u>Biological determinants of lamb survival</u>

The experimental work in this project demonstrated that poor ewe long term protein balance (low blood albumin) in late gestation is associated with an increase in lamb loss between scanning and 24 hours old. This may explain the variable response reported in ewes to additional protein supplementation in late gestation and further work will be required to determine which sheep are most at risk of poor long term protein status and how best to supplement them.

Overall mortality and disease rates within the experimental flock were low and so it was not possible to relate immune status of newborn lambs to mortality, however lambs that grew poorly (bottom 1/3) were more likely to have a blood serum IgG concentration below the 24 mg/ml used as a cut-off for failure of passive transfer in calves. This indicates that even in well run flocks (low mortality and morbidity), poor passive transfer status in lambs has a quantifiable impact on production. This is significant given the wide variation in lamb IgG levels observed.

Of particular note was that there was no association between oral antibiotic therapy and lamb outcomes. This indicates that routine blanket administration of oral antibiotics to newborn lambs does not offer a health or production benefit on farms where disease levels are generally well controlled. This should help farmers have the confidence to stop this practice in line with the responsible use of antimicrobials in animals.

Neonatal survival plan

The findings from this study, along with existing information in the literature were brought together to propose a structured integrated neonatal survival plan that could be used by farmers and their vets to improve neonatal survival. The design of the plan was guided by the findings from the structured interviews, along with the outputs of a meeting held at the University of Nottingham on 30/05/19 to discuss lessons learned from the development of the DairyCo Mastitis Control Plan. This fed into the use of a HACCP (hazard analysis and critical control point) approach to focus on five key areas of management to improve neonatal survival: nutrition, shelter, infection, colostrum and breeding. The management of the farm team was also deemed to be important and included in the overall plan. The framework of the plan is detailed in Figure 28.

This plan was piloted on over 40 farms in Scotland and England in spring 2020. Farms were randomised to receive the plan either before or after their lambing/calving season. The plan was generally positively received by the vets and farmers that trialled it and their feedback was incorporated into the final plan documentation. Data relating to each herd and flock's neonatal survival and antibiotic usage was recorded in both 2019 and 2020 and so future work could explore whether the pilot plan had an impact on farms where it was delivered prior to the calving/lambing period, compared to those farms that did not receive the plan until summer 2020.

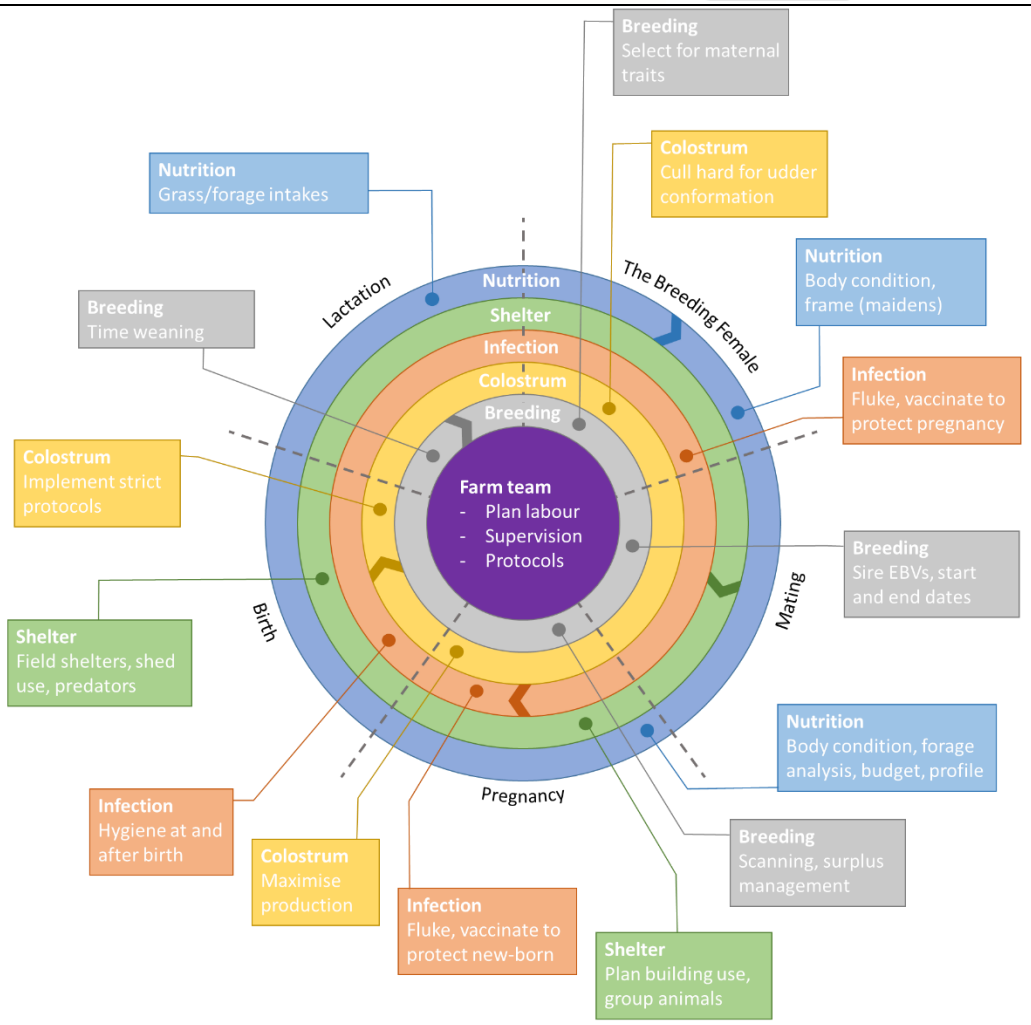

Figure 28: A framework for the delivery of a structured integrated neonatal survival plan

Due to COVID19, the knowledge exchange components of this project have been delayed, with a schedule agreed with the levy boards to ensure that the findings of the project can be effectively communicated to vets and levy payers, with training provided to vets in the implementation of the integrated neonatal survival plan.

Q5 New knowledge: What key bit of new knowledge has come out of this project?

Key Findings

Neonatal survival

- Median GB lamb mortality in first 21 days of life: 8.2% (top quartile 6%)
- Median GB suckler calf mortality in first 21 days of life: 4.4% (top quartile 2.5%)
- Majority of mortality in lambs (8.1%) and calves (4.0%) occurs in the first 7 days of life
- Mortality rates do not vary by farm size or number of breeding females per full time equivalent staff member
- Farmer reported mortality rates in one season do not correlate with observed mortality rates in the subsequent season
- Most suckler farmers have access to reliable mortality records, however 2 in 5 sheep farmers have no record of neonatal mortality at all
- Best practice industry advice with respect to managing neonatal mortality is not consistently followed, particularly with respect to colostrum management and genetic selection

Social sciences

- Neonatal survival is important to farmers
- Farmers demonstrate autonomous motivation to improve neonatal survival and feel confident in their abilities
- Farmers tend to underestimate neonatal mortality on their farm relative to GB averages
- There is a cultural stigma around neonatal losses, which limits farmers in discussing their experiences with their peers and even in some cases, with their vet

Antibiotics

- Reductions in the use of preventive oral antibiotics in lambs are challenging, as their use has historically been viewed as a part of best practice in avoiding losses. However, preventive antibiotics have been reduced or withdrawn successfully on some farms
- Oral antibiotic treatment at birth in a well-run flock does not improve lamb outcomes
- Beef and sheep farms are able to manage infectious disease without purchasing fluoroquinolones, 3rd/4th generation cephalosporins or colistin

Nutrition and colostrum

- Poor long term protein status in late pregnancy (low blood albumin) is predictive of increased lamb loss between scanning and 24 hours old
- Twin born lambs with a serum antibody (IgG) concentration under 24 mg/ml are more likely to have poorer growth rates
- Poor energy balance in late pregnancy (elevated beta-hydroxybutyrate) is predictive of a lamb serum antibody (IgG) concentration under 24 mg/ml
- Lambs supplemented with colostrum are at increased risk of having a serum antibody (IgG) concentration under 24 mg/ml

Q6 Gaps in knowledge: What gaps in knowledge has this project identified?

Whilst this project has described, in depth, the social and behavioural barriers to recording and discussing neonatal mortality, it has not assessed how these can be best addressed. The main output of the project is an integrated neonatal survival plan which can be used by farmers and their veterinary surgeons as a framework to improve neonatal survival in suckler calves and lambs. It is evidence based and builds on the findings of this study. The plan has been piloted on over 40 farms and has been well received, however it is unknown whether it is effective and how it could be optimised over time. This would require investment in improving neonatal survival beyond the two-year timespan of this project, with experience in other areas of animal health such as mastitis and lameness indicating that similar initiatives take a number of years to implement and optimise.

Our understanding of the risk factors for neonatal mortality are still incomplete. Despite extensive efforts to recruit sufficient farmers to explore these risk factors in more detail, the difficultly in engaging farmers with the subject and poor recording makes obtaining sufficient data to fully characterise these risk factors extremely challenging. One potential route in the future would be to make use of the integrated neonatal survival plan to capture neonatal mortality data and to relate differences in performance at the farm level to interventions implemented as part of the plan. This would need to be conducted over a period of 5-10 years, however it would be one way of exploring whether addressing suspected risk factors at the farm level can improve neonatal survival.

The relationship between ewe blood albumin and lamb loss is interesting, however this project has highlighted that we do not have a good understanding of the risk factors for low blood albumin in ewes in late gestation. These are likely to be nutritional in origin, however iceberg diseases e.g. Johne's disease and other diseases like lameness and liver fluke may also be important.

There is very little evidence base to guide when to intervene during lambing/calving.

There is limited evidence to inform the design of appropriate field shelters for lambs.

It is not clear what the best approach is to the management of cows that lose calves in a suckler herd and how to manage triplet lamb litters optimally.

Q7 Additional deliverables: What activity is planned with the results from this project?

Activity	What is planned?	When likely to happen?
Events	Three veterinary face-to-face CPD events	Summer 2021
Press articles	None	N/A
Conference papers, presentations or posters	Five abstracts to BCVA congress. Abstracts to SVS congress SHAWG 2020 online conference	Next conference (COVID19 dependent) 24th November 2020
Scientific papers	Two papers submitted to In Practice Additional papers submitted to Veterinary Record (2) and Preventative Veterinary Medicine (4)	March 2021
Levy communications (specify levy board)	Webinar for levy payers Webinar for vets	January 2021
Social Media	To be managed by levy boards	To coincide with activity in this table
Other	Three video case studies for the levy board websites	July 2021