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Risk factors for stillbirths and mortality during the first 24 h of life on dairy farms in Hokkaido, Japan 2005–2009

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ABSTRACT

This was a retrospective cohort study using data from the insurance scheme provided by the Japanese Mutual Aid Association (NOSAI). The population of interest comprised all cattle born on NOSAI-client farms in the Japanese prefecture of Hokkaido, Japan for the period 1 April 2005–31 March 2009. The outcome of interest was whether or not at least one calf was stillborn, had died during delivery or died during the first 24 hours of life for a given calving event, termed first 24 h mortality risk.

A mixed-effects logistic regression model was developed to identify explanatory variables associated with first 24 h mortality risk. The final data set comprised details of 1,281,737 calving events on a total of 5172 dairy herds from 19 NOSAI branches located throughout the prefecture of Hokkaido. Throughout the study period 7.68 (95% CI 7.64–7.73) of every 100 calving events had at least one calf that was either stillborn, dead at the time of delivery or dead during the first 24 h of life.

Factors that were positively associated with an increase in first 24 h mortality risk included delivery during the colder months of the year (November–March), being of Wagyu breed, having a multipara dam, multiple (as opposed to single) birth deliveries, and delivery in larger herds. After adjusting for the fixed effects included in our multilevel model, 89% of the unexplained variation in first 24 h mortality risk was at the calving event level. We propose that the data recording requirements of the NOSAI scheme are extended to include details of calving events (e.g. the presence or absence of dystocia) and details of the way in which calves are managed post delivery. This would allow more subtle risk factors for calf mortality to be identified which, in turn, will lead to refinement of recommendations for calf management during the first 24 h of life in this area of Japan.

1. Introduction

Factors influencing the risk of mortality in dairy calves during the first three months of life have been investigated in a number of countries including the USA (Jenny et al., 1981; James et al., 1984; Curtis et al., 1988a, 1988b), Canada (Waltner-Toews et al., 1986a, 1986b, 1986c, 1986d), France (Fourichon et al., 1997), Belgium (Pardon et al., 2012), Switzerland (Busato et al., 1997), Sweden (Olsson et al., 1993; Svensson et al., 2003; Lundborg et al., 2005; Torsein et al., 2014), Kenya (de Clare Bronsvoort et al., 2013), and Iran (Azizzadeh et al., 2012). A number of consistent risk factors for calf mortality have been identified, including the housing of animals in groups (Waltner-Toews et al., 1986d; Olsson et al., 1993; Willard et al., 1996), the use of indoor housing (instead of outdoors, in hutches), the routine use of antibiotics to treat cases of diarrhoea (Lance et al., 1992), inadequate passive transfer of colostral immunoglobulin (Jenny et al., 1981; Wells et al., 1996; Tyler et al., 1999), being born to a first lactation heifer (Olsson et al., 1993), twin births (Wells et al., 1996; Silva del Rio et al., 2007; Ghavi Hossein-Zedeh et al., 2008; Gulliksen et al., 2009), provision of assistance to effect delivery (Waltner-Toews et al., 1986d; Wells et al., 1996; Lombard et al., 2007; Gulliksen et al., 2009), and being separated from the dam for more than 24 h following delivery (Jenny et al., 1981; Wells et al., 1996). Most of the calf mortality studies cited above were of a prospective cohort design, wherein herd managers were recruited as study participants and cohorts of calves were followed over periods of up to 90 days from birth to document disease and mortality events and their reasons. Few studies have explicitly

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quantified calf mortality risk or risk factors for mortality in the 24 h immediately following delivery.

Insurance schemes provide consumers with financial protection for their assets against specified contingencies through the payment of regular premiums in return for a policy guaranteeing such protection. While insurance policies are commonly taken out by individuals and businesses to offset costs arising from loss of property, vehicles, employment and life, insurance schemes for farmed livestock are uncommon and even in jurisdictions where they are available, uptake by livestock producers tends to be low (USDA, 2015). A notable exception is the Japanese Mutual Aid Association (NOSAI). Under this system, established in 1947, cattle older than 6 months of age are insured for death and a list of pre-defined involuntary culling reasons (NOSAI, 2015). Depending on the level of insurance coverage, herd managers are compensated in the event that an animal dies or is involuntarily culled. In 2004 the NOSAI scheme was extended to include foetuses over 240 days of gestation and calves less than 6 months of age. In 2013 herd managers paid approximately JPY 7750 (approximately USD 65) per cow per year for death and involuntary culling insurance. The actual cost of insurance per cow per year in 2013 was JPY 15,424 (approximately USD 130) because the Ministry for Agriculture, Forestry and Fisheries (MAFF) subsidised one-half of the total insurance costs. When a veterinarian is called to treat an animal, the herd manager pays the visit fee, with insurance covering the cost of some or all of the medication and/or therapeutic procedures prescribed as part of that visit.

A key advantage of livestock insurance schemes (such as NOSAI) is that the quality of on-farm records pertaining to births, sales, deaths and health events for individual animals are uniformly high across participating herds. Analyses of insurance records at either the regional or national level, particularly when scheme participation rates are high, can be informative because they provide both accurate and precise estimates of the 'normal' level of mortality for different classes of stock.

The aim of this study was to use calving event records kept by the NOSAI for dairy herds in Hokkaido, Japan for the period 1 April 2005–31 March 2009 to identify risk factors for mortality in calves that were either stillborn or born alive but died during the first 24 h of life. A knowledge of factors adversely influencing the probability of stillbirth and death in the first 24 h in calves is important for two reasons. Firstly, modifying exposure to management or environmental factors known to be causally associated with mortality stands to minimise preventable losses in commercial dairy herds, with positive impacts on animal welfare. Secondly, reducing the level of involuntary calf loss provides herd managers with the opportunity to be more selective when choosing animals to join the replacement herd. Over time, this strategy stands to result in an increase in the genetic worth of the milking herd, with corresponding increases in herd profitability.

2. Materials and methods

2.1. Data

This was a retrospective cohort study of risk factors for stillbirths, deaths during delivery and mortality in the first 24 h of life in Hokkaido dairy cattle. The population of interest comprised all dairy cows on NOSAI-client farms in the Japanese prefecture of Hokkaido, Japan for the period 1 April 2005–31 March 2009. Throughout the study period approximately 80% of all dairy herd owners in Hokkaido participated in the NOSAI scheme. Data were retrieved in digital format from the Hokkaido NOSAI office for all calving events that occurred throughout the study period. Details for each calving event included the unique national identifier of the farm on which the delivery occurred, the date of delivery, the unique national animal identifier of the dam, the parity of the dam at the time of delivery, the number of calves delivered by the dam, and calf breed. Delivery of twins (or triplets) was defined as a single calving event for the dam. Herd size was a derived variable equal to the total number of recorded deliveries for each herd over the 4 year study period divided by 4, assuming that, on average, cows calved once every 12 months. The outcome of interest for this study was a binary response variable, Y_i, taking the value 1 if a calving event had at least one calf that was either stillborn, dead at the time of delivery or died during the first 24 h of life and 0 otherwise. In the remainder of this paper we use the term 'first 24 h mortality' as a descriptor for this outcome. The final data set comprised details of 1,281,737 calving events on a total of 5172 dairy herds from 19 NOSAI branches (offices) located throughout the prefecture of Hokkaido.

2.2. Statistical analyses

Twenty-four small-scale dairy herd operations (where the total number of calves born over the 4 year study period was less than 10) were excluded from our analyses since they were considered to be atypical of the population of commercial dairy herds in Hokkaido. First 24 h mortality incidence risk over the 4 year study period was calculated as the total number of calving events that had at least one calf that was either stillborn, dead at the time of delivery or died during the first 24 h of life as the numerator and the total number of deliveries as the denominator. First 24 h mortality incidence risk estimates were stratified by time of the year in which the calving event occurred (April to October defined the warmer months; November to March defined the colder months), breed, parity of the dam at the time of delivery, litter size (the number of calves delivered by the dam for given calving event) and average herd size (small: less than 50 cows; medium: 50–150 cows; large: greater than 150 cows). Herds were sorted in order of first 24 h mortality incidence risk and an error bar plot produced showing mortality risk (and its 95% confidence interval) as a function of herd rank. The purpose of this plot was to show the amount of between-herd variation in first 24 h mortality incidence risk.

Unconditional associations between each of the hypothesised explanatory variables and the outcome of interest were computed using the odds ratio. Explanatory variables with unconditional associations significant at the $P < 0.20$ level (2-sided) were selected for multivariable modelling.

In the first instance, a fixed-effects logistic regression model was developed where the probability of death in the first 24 h was parameterised as a function of the explanatory variables with unconditional associations significant at $P < 0.20$, as described above. Explanatory variables that were not statistically significant were removed from the model one at a time, beginning with the least significant, until the estimated regression coefficients for all explanatory variables retained were significant at an alpha level of less than 0.05. Explanatory variables that were excluded at the initial screening stage were tested for inclusion in the final model and were retained in the model if their inclusion changed any of the estimated regression coefficients by more than 20%. Biologically plausible two-way interactions were tested and none were significant at an alpha level of 0.05.

To account for the hierarchical structure of the data, that is, calving events clustered within cows (dams) and cows clustered within herds we extended the model to include cow- and herd-level random effect terms. This extension to the model was informative because it provided the opportunity to distinguish the influence of the calving event, the dam and the herd (a proxy for management) on first 24 h mortality risk.