The impact of the age structure in Dutch dairy herds on surveillance indicators

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Summary

Understanding how demographic structures influence routinely monitored indicators is essential for accurate interpretation of cattle health surveillance outputs. Using near-census data from the Dutch Cattle Health Surveillance System (CHSS), this study quantified how dam age contributes to variation in key surveillance indicators, including perinatal, postnatal and pre-weaned calf mortality, as well as twin births. More than 2.4 million dairy cows were evaluated (2019–2023), and multivariable mixed-effects logistic regression models were applied across dam-age categories (<3 years, 3–5 years, 6–8 years, >8 years) while accounting for herd-level and temporal factors. Younger (<3 years) and older (>6 years) dams showed elevated odds of perinatal mortality compared with the reference category, and young cows also exhibited higher postnatal mortality risk. Twin births followed a clear age-dependent pattern, peaking in mid-aged cows before declining in the oldest group. Dam age demonstrated the strongest association with each surveillance indicator relative to other herd-level factors. These results show that shifts in herd age structure - such as those driven by longevity strategies - can meaningfully influence national surveillance trends. Incorporating dam-age structure into the design, interpretation and communication of operational monitoring systems is therefore essential to avoid misinterpretation of demographic variation as emerging health problems. This surveillance-informed understanding supports more accurate signal detection and more reliable policy and management decisions within the dairy sector.

Introduction

Routine animal health surveillance systems in dairy production are primarily designed to monitor key health and performance indicators over time. These systems enable the continuous assessment of population-level outcomes, such as calf mortality and reproductive performance, and support the identification of trends, shifts, and emerging risk patterns within herds.

Effective monitoring requires understanding how structural changes in the population influence observed indicators. Animal health can change for multiple reasons, including emerging diseases, management or sectoral developments, and demographic shifts such as ageing of the herd. In recent years, increased dairy cow longevity has altered herd age structure. Consequently, trends in monitored indicators may reflect not only true health or management changes, but also demographic composition. Distinguishing between these causes is essential for correct interpretation of surveillance outcomes. Dam age can potentially explain observed variation in several routinely monitored indicators. Young cows, particularly primiparous heifers, have an increased risk of dystocia due to incomplete skeletal development, contributing to higher perinatal mortality (1, 2). At the other end of the age spectrum, older cows experience age-related declines in reproductive efficiency and increased susceptibility to metabolic disorders, which may affect calf survival (3). In addition, the probability of twin pregnancies increases with age and production level due to higher rates of double ovulation (4). Twin births are associated with a range of adverse outcomes, including dystocia, retained placenta, metabolic disease, reduced fertility, and increased culling (5), and are therefore relevant to monitor alongside mortality indicators.

Despite the routine availability of these indicators, limited insight exists into how variation in dam age contributes to observed patterns in monitoring data at population level. In particular, the combined effect of age structure on both calf mortality and twinning remains insufficiently quantified, while accounting for herd-level and temporal variation. Improved understanding of these relationships is necessary to correctly interpret monitored trends and to identify meaningful deviations from expected patterns. This study aims to quantify how dam age contributes to variation in routinely monitored indicators within a national cattle health surveillance system. Specifically, the study:

* Quantifies associations between dam age and perinatal, postnatal, and pre-weaned calf mortality, as well as twin births, using large-scale monitoring data;
* Evaluates how differences in herd age structure influence observed patterns in these indicators over time;

* Supports improved interpretation of monitoring outputs by identifying age-related baseline patterns and risk profiles.

Material and methods

Study population
Data originated from the Dutch Cattle Health Surveillance System (CHSS), which includes near-census information from approximately 98% of Dutch dairy herds. Records from the first quarter of 2019 to the fourth quarter of 2023 were analysed, comprising data of on average 2.43 million female cattle per quarter.

Definitions
Dam age was recorded quarterly. Mortality and twinning outcomes were defined as:
* Perinatal mortality: death before the moment of ear-tagging i.e. late abortions, stillborn or death within 3 days after birth since it is mandatory by law to tag newborn calves within a maximum of 3 days after birth.
* Postnatal calf mortality (0–14 days): liveborn calf received an ear tag but died ≤14 days.
* Pre-weaned calf mortality (15–56 days): death between 15 and 56 days.
* Twin births: >1 calf per calving.

Data cleaning and processing
Encrypted raw data from different data sources (including data on cattle movement registrations, milk production, herd health statuses and veterinary registration of antimicrobial deliveries) were imported into SAS 9.4 for validation and processing. Records were checked for biological plausibility, internal consistency, and completeness; implausible values were set to missing. All datasets were merged into a single analytical file structured at the cow-quarter level. Each cow received one record per quarter, regardless of whether a calving occurred. For descriptive analysis, proportions of calvings resulting in each outcome were calculated for each dam-age category (year) per quarter of the year within the analysed period. Standard errors were included and visualised in plots to reflect precision.

Model structure and statistical analysis
To evaluate associations between dam age and each outcome, multivariable mixed-effects logistic regression models were fitted using Stata 17. Dam age was the primary variable of interest and was categorised as: <3 years, 3-5 years, 6-8 years, or >8 years. These categories reflect biologically meaningful stages of the productive lifespan and ensured adequate sample sizes. For each quarter, calving events were identified and outcomes assigned sequentially:
* If a calf was born, it could either be alive or dead during the perinatal stage
* If a calf was ear-tagged, it could subsequently live until 15 days old or die during the postnatal period
* If a calf entered the pre-weaned stage, it could either die during this period or live and enter the weaned period at 56 days old.
* If a calving took place, it was evaluated whether more than 1 calf was born, indicating a twin birth.

Each model included a random cow-level and herd-level variable, and included other explanatory variables such as herd size, milk production level, region, season and trend in time. Because of computational constraints in handling 48 million records per outcome, each model was fitted using random subsamples of up to 5 million cow-quarter records. Each model was repeated three times. Results were considered stable and robust when ORs and CIs were nearly identical across runs.

Results

The proportion of older cows (>8 years) increased from 3.3% in Q4 2019 to 4.6% in Q4 2023. Perinatal calf was highest in dams <3 years (10.1%), lowest in 3–5-year-old dams (4.3-4.7%) and increased again in older age groups (5.3-7.4% in cows >8 years). Postnatal calf mortality (≤14 days) and pre-weaned calf mortality (15–56 days) were similarly highest in <3-year dams and declined and stabilized gradually in older cattle. Twin births were at their lowest in cows <3 years (around 0.5%), peaked at 6–8 years (~4.1%) before declining in >8-year dams (around 3% in cows ≥13 years) (Figure 1).

Multivariable results
The multivariable models showed that dam age was strongly associated with calf mortality and twin births. A dam younger than 3 years was associated with higher odds of perinatal calf mortality compared with the reference category (OR = 2.30; 95% CI: 2.24–2.35). Calves with dams aged 6–8 years also had increased odds of perinatal mortality (OR = 1.19; 95% CI: 1.16–1.22), as did calves with dams over 8 years old (OR = 1.54; 95% CI: 1.47–1.61). Across all explanatory variables included in the model, dam age showed the strongest association with perinatal calf mortality.

For postnatal calf mortality, associations with dam age were also observed. Young ear tagged calves (≤14 days old) with dams younger than 3 years had increased odds of mortality (OR = 1.10; 95% CI: 1.06–1.14), whereas calves with dams aged 6–8 years had lower odds (OR = 0.96; 95% CI: 0.93–1.00). Calves with dams >8 years were associated with higher odds for calf mortality (OR = 1.07; 95% CI: 1.00–1.14), however this association was not significant (P=0.06). The model for pre-weaned calf mortality did not converge. As a result, no adjusted effect estimates are reported for this outcome.
Dam age was also strongly associated with the occurrence of twin births. Cows <3 years had lower odds to give birth to more than one calf (OR = 0.19; 95% CI: 0.18–0.20), whereas cows aged 6–8 years (OR = 1.33; 95% CI: 1.29–1.37) and >8 years (OR = 1.27; 95% CI: 1.20–1.35) had higher odds of twin births compared to cows 3-5 years. These age-related effects were stronger than those observed for other explanatory variables in the model.

Discussion

This study demonstrates that dam age is a major determinant of variation in routinely monitored indicators such as calf mortality and twin births. The observed associations show that herd demographic composition substantially influences the levels of these indicators. This has direct implications for how monitoring results are interpreted within animal health surveillance systems.
Monitoring systems are designed to identify unusual changes or emerging problems over time. However, indicator levels are not only influenced by health events or management factors, but also by structural characteristics of the herd. The results show that dam age is one of these structural characteristics. Differences in age distribution between herds, or gradual shifts in age structure over time, can therefore influence observed mortality and twinning rates independently of new or emerging disease issues. Moreover, age structure is also essential when comparing populations, as differences in calf mortality between herds or regions may partly reflect demographic composition rather than true differences in health status.
The elevated perinatal mortality observed in young cows (<3 years) is consistent with known risks related to dystocia and reduced neonatal vitality in primiparous heifers (1, 2). In monitoring practice, herds with a relatively high proportion of young animals may show persistently higher perinatal mortality compared with herds with a higher proportion of mature cows. Without considering age composition, such differences could be misinterpreted as deteriorating herd performance.
In older cows, increased perinatal mortality likely reflects age-related physiological changes, including greater susceptibility to metabolic disorders (3). At the same time, the absence of a strong progressive increase in mortality suggests that increasing longevity does not automatically lead to marked increases in monitored calf losses. The clear age-dependent pattern in twin births further illustrates how demographic composition influences monitoring results. Because twin pregnancies are associated with adverse health and performance outcomes (4, 5), rising twinning rates may attract attention within surveillance systems. However, the findings indicate that such increases may partly reflect a higher proportion of older cows rather than new reproductive problems. Interpreting twinning rates in relation to age structure can therefore improve the accuracy of monitoring conclusions.
Several limitations should be considered. Misclassification of dam age due to quarterly recording may have slightly weakened observed associations. Moreover, age was the only cow-level factor in the models while other variables were on herd-level. In addition, breeding strategies, such as the use of beef semen in older cows, may influence calf outcomes and interact with age effects.
Overall, this study shows that demographic structure, and dam age in particular, is essential for correctly interpreting routinely monitored calf mortality and twin births. Incorporating age distribution into monitoring frameworks can improve the detection of meaningful changes while reducing the risk of false alarms, thereby strengthening the effectiveness of animal health surveillance systems.

Conclusion

Integrating dam age into routine monitoring frameworks is essential to correctly interpret variation in calf mortality and twin births. This improves the performance of surveillance systems by reducing misinterpretation and supporting more reliable identification of true health signals

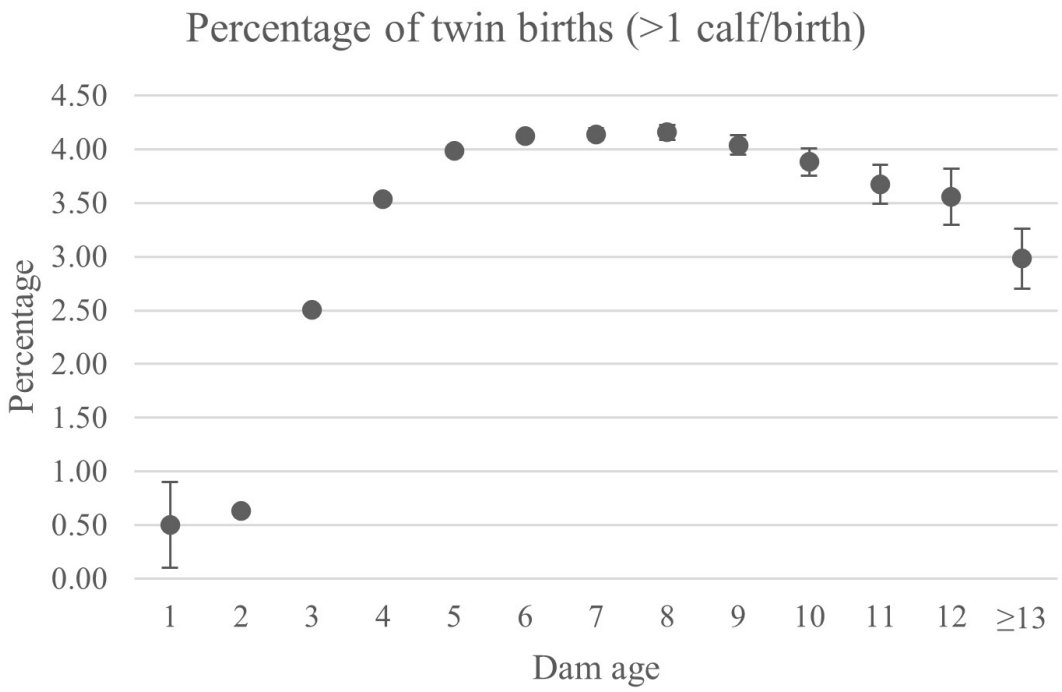


Figure 1. Percentage of twin births (at least two calves born per birth) per age group of dams (varying between one and ≥13 years old).

Keywords: Dam age, Calf mortality, Twin births.

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