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Recording of calf diseases for potential use in breeding programs: a case study on calf respiratory illness and diarrhea

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Abstract

Calf diseases remain a challenge for dairy producers from both an economic and welfare perspective. Genetically selecting for disease resistance in calves is a promising approach that could contribute to sustainable dairy farming. Genetic evaluations, however, require well-defined and consistently recorded phenotypes to be successful. Therefore, this study aimed to understand the current state of calf disease recording on Ontario farms. Calf disease records of respiratory illness and diarrhea were available from the national milk recording organization (Lactanet Canada, Guelph, Ontario, Canada) from 2009 to 2020. A case study was conducted to describe calf disease diagnoses and recording practices by surveying a subset of 13 Ontario dairy producers. The percentage of milk recorded farms that recorded calf respiratory illness and calf diarrhea increased from 2.6% in 2009 to 11.1% in 2020. Potential sources of data loss were identified along the information chain from farm to genetic evaluation database. Clear definitions and thresholds to diagnose calf disease, standard operating procedures for data recording, as well as a data transfer pipeline, which includes exchange formats, are needed to facilitate the inclusion of calf health traits in genetic evaluations.

Key words: calf health, data recording, genetics, pneumonia, scours

Introduction

Breeding goals in dairy cattle are increasingly broadening beyond production to include a range of traits related to fertility, longevity, animal health, and welfare (Miglior et al. 2017; Brito et al. 2021). Advances in genetics and genomics have allowed for improvements in animal health despite many of these traits having low heritability (Philipsson and Lindhé 2003; Miglior et al. 2017; Guarini et al. 2019; Cole et al. 2021). The recording of accurate and high quality phenotypes remains an important requirement (Coffey 2020; Seidel et al. 2020). These phenotypes can be collected from different sources, such as voluntary producer-recorded data, milk recording companies, or national databases, and may originally be collected for management, herd improvement, health surveillance, or genetic evaluation purposes (Kelton et al. 1998; Espetvedt et al. 2012; Velasova et al. 2015; Gonzalez-Peña et al. 2019). These sources may differ in recording standards, data quality, reliability, or accuracy, and thus cannot always be integrated (Kelton et al. 1998; Espetvedt et al. 2012; Velasova et al. 2015). However, when efficient recording systems are available and integrated, the use of health data for disease surveillance and genetic improvements is possible (Philipsson and Lindhé 2003; Espetvedt et al. 2012; Fleming et al. 2018).

In Canada, voluntary recording of eight common cow diseases by producers (or veterinarians) has enabled the estimation of genetic parameters and prediction of breeding values for mastitis, displaced abomasum, ketosis, milk fever, retained placenta, metritis, cystic ovaries, and lameness (Kelton et al. 1998; Koeck et al. 2012; Neuenschwander et al. 2012). Cow health traits have been prioritized due to the economic relevance of these animals (Pryce et al. 1997; Philipsson and Lindhé 2003; Zwald et al. 2004; Haile-Mariam and Goddard 2010; Koeck et al. 2012; Parker Gaddis et al. 2014; Vukasinovic et al. 2017). However, it is becoming increasingly recognized that calf health is crucial as it can have long-term effects on cow health and production later in life (Svensson and Hultgren 2008; Heinrichs and Heinrichs 2011; Dunn et al. 2018; Buczinski et al. 2021). Additionally, societal concerns regarding calf health are also important factors in dairy production in Canada (National Farm Animal Care Council 2019; Dairy Cattle Code of Practice Scientific Committee 2020). Calf respiratory illness and calf diarrhea are considered a high priority by the dairy industry due to their high incidence, short- and long-term effects on calf health and performance, as well as increased risk of mortality or exit from the herd (Gulliksen et al. 2009; More et al. 2010; Stanton et al. 2012; Bauman et al. 2016; Closs and Dechow 2017; USDA 2021). Murray (2011) reported that calf mortality in Canada ranged between 7% and 11%, and 53% of calf mortality was attributed to diarrhea and 21% to respiratory illness. Consequently, many international efforts have aimed at estimating genetic parameters for calf health traits (Heringstad et al. 2008; Fuerst-Waltl et al. 2010; Henderson et al. 2011*a*, 2011*b*; McCorquodale et al. 2013; Gonzalez-Peña et al. 2019; Johnston et al. 2020; Zhang et al. 2022), showing low heritability for calf diarrhea (range: 0.03–0.06), calf respiratory illness (range: 0.04–0.09), and calf mortality (range: 0.001–0.12). This suggests that selection for these traits is possible, but, with the exception of the Clarifide Plus product (Zoetis 2018) and the new Calf Immunity Index (Semex 2022), the incorporation of these traits in routine genetic evaluations is limited to date.

A major barrier to including calf health traits in genetic evaluations is the lack of routine recording of calf health phenotypes (McCorquodale et al. 2013; Gonzalez-Peña et al. 2019). In Canada, the recording of calf mortality is required and keeping detailed and accurate health records is recommended (National Farm Animal Care Council 2009; Dairy Farmers of Canada 2020). There are currently no definitive requirements or standardized criteria in place for the recording of calf health. Farms that participate in milk recording through dairy herd improvement (DHI) programs, a milk recording and data management service offered by Lactanet Canada (Guelph, Ontario, Canada), may voluntarily include disease events as producers deem necessary (Koeck et al. 2012; Neuenschwander et al. 2012).

The Resilient Dairy Genome Project (http://resilientdairy.ca/) aims to broaden the health portfolio for genetic evaluations in Canada to include calf health traits (Baes et al. 2021). To be able to include producer-recorded calf health traits in breeding evaluations, it is key to first understand the type and quality of records currently available and how recording is performed on-farm. The objectives of this study were therefore to assess calf disease recording practices (i.e., for respiratory illness and diarrhea) and perform an initial evaluation of the data currently available from producers in Ontario enrolled in DHI for potential use in a genetic evaluation program. A case study was conducted to gain insights into calf disease diagnosis, recording practices, and data quality by surveying a subset of Ontario dairy producers.

Materials and methods

Calf disease records from farms enrolled in DHI in Ontario

Calf disease data recorded by dairy producers through management software were provided by Lactanet Canada (Guelph, Ontario, Canada). It comprised 36 392 Canadian Holstein calf disease records for respiratory illness and diarrhea, collected on 538 dairy herds in Ontario (Canada) for animals less than 60 days of age from 2009 to 2020. A total of 20 501 records were used in the analysis after data validation and cleaning. To be considered in the analysis, a minimum annual disease incidence rate of 1% was required for each disease in each herd per year to ensure consistent data recording as per Koeck et al. (2012) and Haagen et al. (2021). This was estimated using the number of disease events in a herd per year over the total number of calves raised on that farm in a given year. Additionally, herds needed to have a minimum of two consecutive years of calf disease records available within the data collection period, or only records available in 2020 which were considered to be herds that just started recording. These steps were undertaken to provide insight into which herds were consistently collecting calf disease information and who most likely had consistent recording practices.

Case study on calf disease recording practices in Ontario farms

A survey was developed to collect information about calf disease recording practices. The survey was provided to a convenience sample of producers in Southwestern Ontario known to have good on-farm recording practices that were already participating in the Canadian Dairy Network for Antimicrobial Stewardship and Resistance. This network aims to improve stewardship of antimicrobial use on Canadian dairy farms (Fonseca et al. 2022). To be eligible for the current study, farms had to be enrolled in DHI and had to be recording calf respiratory illness and calf diarrhea within on-farm recording systems. This allowed for the identification of current recording practices and potential gaps that need to be addressed to improve data quality and use calf disease records for genetic purposes. The survey was submitted to the University of Guelph Research Ethics Board and received an exemption from full review as no identifying information was collected and the focus of the research was exclusively on the animals. Completion of the survey indicated a producer's informed consent to participate.

The survey consisted of predominantly semi-closed questions with instructions on whether only one or multiple answers could be selected. Producers were asked to consider pre-weaning calves of less than 60 days of age. The main topics covered within the survey included the diagnoses of calf disease events and calf disease recording practices on-farm, with a focus on respiratory illness and diarrhea. Questions related to the diagnosis of disease events by producers were based on the Pennsylvania State University calf observation scoring system (Heinrichs and Jones 2016) and the University of Wisconsin-Madison School of Veterinary Medicine calf health scoring guide (McGuirk 2008). Producers were asked to indicate which indicators (rectal temperature, coughing, nasal discharge, alertness, and fecal score) they use, and at which threshold, to diagnose a calf with respiratory illness or diarrhea. Rectal temperature and alertness were provided for both diseases, while coughing and nasal discharge were specific to respiratory illness, and fecal score was specific to diarrhea.

For both diseases and mortality, producers were also asked how they were recorded, either through computer-based or paper-based systems, or both. This included what pre-set codes were used in the computer-based system or standardized shorthand notation in paper-based systems. Additionally, producers were asked to indicate any additional information that was captured through the recording system (i.e., signs of illness, treatment, and cause of death) and who could enter data on the recording system. General questions related to colostrum, feeding, and housing management of pre-weaning calves were included and are reported in Hyland (2022). The survey was provided via email with a direct link to the survey on Microsoft Forms (Office 365, 2016) and data were directly exported to Microsoft Excel (Office 365, 2021). Descriptive statistics were calculated using R Statistical Software version 3.6.3 (R Core Team 2020). Survey frequency tables were calculated to determine the number and percentage of responses, and the average and the range of the temperature thresholds used during diagnosis.

Results and discussion

Calf disease records from farms enrolled in DHI in Ontario

The number of farms in Ontario with accessible calf disease records via DHI increased from 2009 to 2020 (Table 1). More farms reported on respiratory illness than diarrhea, likely due to the larger impact of respiratory illness from both an animal health and economic point of view compared to diarrhea, which is relatively easier to identify and manage (Murray 2011; Bauman et al. 2016). When considering the proportion of farms on DHI reporting respiratory illness and diarrhea, an increase from approximately 2.6% in 2009 to 11% in 2020 was observed (Fig. 1). This is lower than the proportion of farms under milk recording that regularly record disease events as reported by Koeck et al. (2012) in first lactation cows in Canada (40% of herds) and by Egger-Danner et al. (2012) in first and second lactation cows in Austria (65% of herds). This discrepancy, however, was not unexpected. Traditionally, the focus has been on cows for herd management and genetic evaluations of cow diseases in Canada (Kelton et al. 1998; Koeck et al. 2012; Bauman et al. 2016), but no such system or incentive is in place for calf disease recording.

It may be that records exist on-farm for internal management purposes, but these are not entered into recording software or other formats accessible to Lactanet Canada. Data loss can occur in various steps in the process including (*i*) sick calves not being observed on-farm, (*ii*) sick calf information not or incorrectly being recorded on-farm, and (*iii*) recorded sick calf information not entering centralized databases due to herds not being enrolled on the DHI systems, data transfer errors, or herds being excluded during quality control (Fig. 2). These points of data loss could limit the amount of data available to use in genetic evaluations and should be minimized. The development of a cost-effective data pipeline is a requirement for including novel traits in routine genetic evaluations (Miglior et al. 2016).

Even when considering disease events for cows, not all data are transferred from producers to national databases, as observed in Nordic countries (Espetvedt et al. 2012). Specifically, only between 69% and 79% of milk fever, 46% and 77% of ketosis, and 33% and 81% of "other metabolic disease" diagnostic events made by producers ended up in the national Nordic databases (Espetvedt et al. 2012), highlighting variation in the amount of data that can reach centralized databases. Similarly, more herds were reported with coughing or gastrointestinal disorders (including diarrhea) in young stock by producer data compared to disease databases (Mörk et al. 2009). It was suggested that the majority of record losses occurred at transfer between databases and variation in the completeness of records was dependent on the type of disease, region, and veterinarian involved in disease recording (Mörk et al. 2010). In Canada, Denis-Robichau et al. (2019) reported that over 90% of surveyed farms kept health records; this included nearly 72% keeping individual records for each animal in the herd, nearly 13% keeping individual records for each adult animal in the herd, and 8.5% keeping records of disease events for specific diseases. It is unclear if these records also included calves. In general, it is difficult to find specific information on health records for calves. Dutil et al. (1999) reported that 70%–85% of 520 cow-calf producers in Quebec kept records related to, e.g., calf weights, age of cows, disease events, or treatments. The higher percentage of record-keeping in that study likely relates to more general record-keeping aspects rather than calf health per se, which makes comparison to the current study difficult. Furthermore, practices were self-reported (Dutil et al. 1999; Denis-Robichaud et al. 2019), as opposed to a tally of actual farms with records observed in a database, as in the current study. However, the on-farm validations of the ProAction biosecurity module on 2447 farms between 2019 and 2020 in Canada indicated that 83% of farms recorded the occurrence of disease events for cows and calves (Dairy Farmers of Canada 2021*a*). It is unclear how many of these farms have calf disease records that could be made available centrally. Addressing the barriers that prevent the uptake and sharing of calf disease recording in a standardized manner on a Canada-wide scale may help to incorporate calf health traits into genetic evaluations.

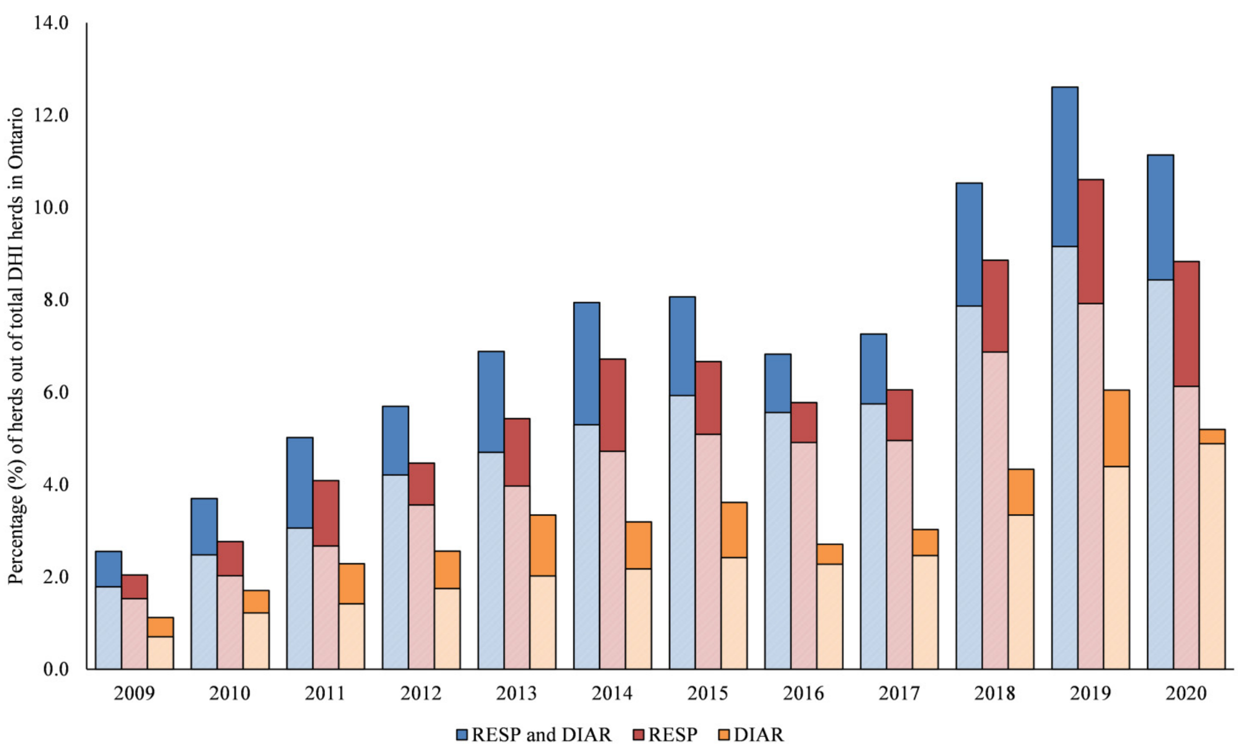
Highlighting the benefits of disease recording for both herd management and genetic evaluations to dairy producers to motivate financial and time investments were also previously recommended (Wiggans 1994; Koeck et al. 2012). Providing clear definitions of calf diseases, similar to the work done by Kelton et al. (1998) for cow diseases, might be the best way to encourage recording, especially if standardized formats for data exchange are provided (Wiggans 1994). Large amounts of data may be lost after data evaluation, as was seen in the current study (Fig. 1) as well as for cow health data (Pryce et al. 1997; Zwald et al. 2004; Haile-Mariam and Goddard 2010; Koeck et al. 2012). On average, approximately 28% of herds that provided calf disease records were removed after data editing in the current study. As a result, the percentage of herds on DHI that provided calf disease data decreased from 11.1% to 8.4% when considering both respiratory illness and diarrhea (Fig. 1). As data are provided voluntarily, there is a risk of bias, under-reporting, and lack of quality control on-farm (Velasova et al. 2015).

Table 1. Total number of milking herds, total number of milking herds on dairy herd improvement (DHI), and total number of milking herds with calf disease records (respiratory illness—RESP; calf diarrhea—DIAR) in Ontario.

			Before editing			After editing		
Year	No. of herds (total)	No. of herds on DHI	No. of herds with RESP	No. of herds with DIAR	No. of herds with RESP and DIAR	No. of herds with RESP	No. of herds with DIAR	No. of herds with RESP and DIAR
2009	4243	3136	64	35	80	48	22	56
2010	4191	3112	86	53	115	63	38	77
2011	4137	3110	127	71	156	83	44	95
2012	4083	3091	138	79	176	110	54	130
2013	3997	3024	164	101	208	120	61	142
2014	3926	2948	198	94	234	139	64	156
2015	3834	2853	190	103	230	145	69	169
2016	3731	2771	160	75	189	136	63	154
2017	3613	2645	160	80	192	131	65	152
2018	3534	2518	223	109	265	173	84	198
2019	3446	2349	249	142	296	186	103	215
2020	3367	2254	199	117	251	138	110	190

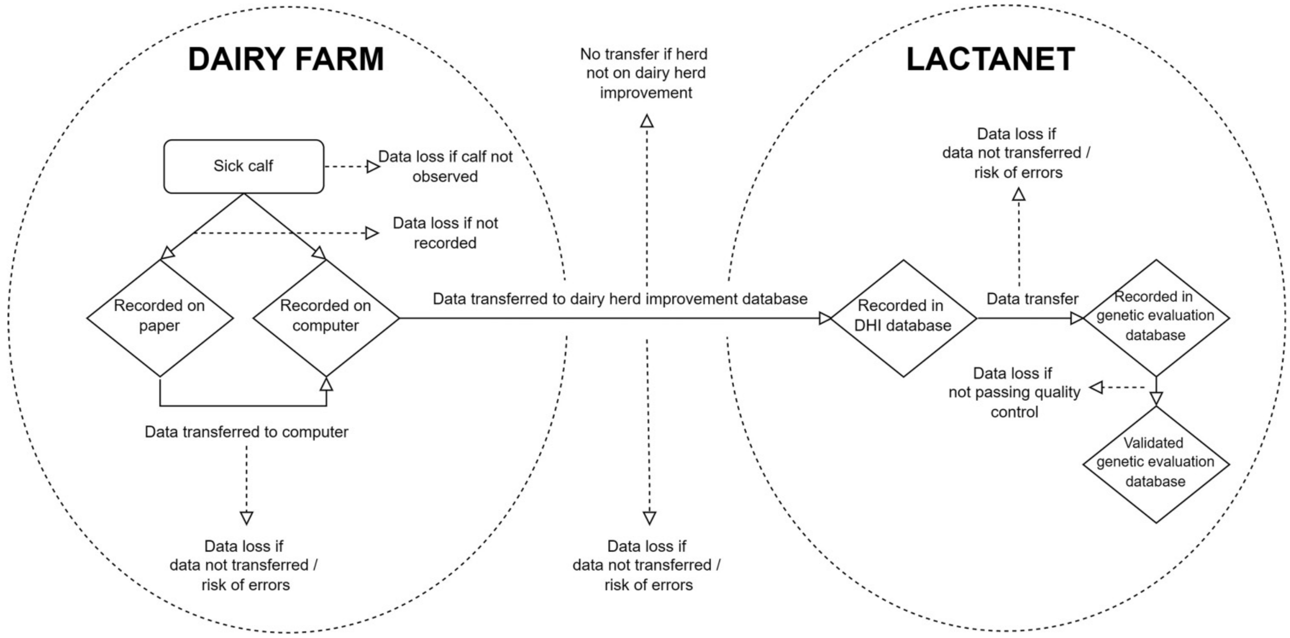
Note: Number of herds is presented for each condition separately as well as both conditions together. Number of herds after editing includes the removal of herds that had less than two consecutive years of data recording (except for herds that only had records in 2020).

Fig. 1. Percentage (%) of herds that provide records on respiratory illness (RESP) or diarrhea (DIAR) in calves out of the total herds on dairy herd improvement (DHI) in Ontario for each specific year. Solid dark bars plus light bars indicate percentage of herds before data editing, and light bars indicate percentage of herds after data editing (i.e., the removal of herds that had less than two consecutive years of data recording except for herds that only had records in 2020).



Herds are more likely to be removed in data validation steps if the amount of recording is low, inconsistent, or improbable (e.g., extremely low incidence rates (Neuenschwander et al. 2012)). It is noteworthy that while diarrhea was less frequently recorded compared to respiratory illness, fewer herds were removed for the diarrhea trait during data editing (Fig. 1). Possibly, the current threshold of 1% was not sufficiently high for diarrhea, meaning that fewer herds were excluded for this trait; however, others have used a 0.5% threshold for diarrhea and respiratory disease in calves (Gonzalez-Peña et al. 2019). Further work should identify the appropriate minimum thresholds and exclusion criteria for data

Fig. 2. Theoretical data flow from farm to Lactanet Canada for calf disease records for genetic evaluation.



validation of calf health traits. However, even with herds potentially being discarded due to unreliable recording, genetic evaluations are still possible as long as enough high-quality data are available and recording is consistent. Furthermore, Koeck et al. (2012) noted that while the number of herds recording cow health data only showed a slight increase over three years, the number of disease cases substantially increased. This indicates that producers may increase their recording efforts, keeping more accurate and complete disease records over time (Koeck et al. 2012) and that similar improvements may be expected when it comes to calf disease recording. Both the number of herds before and after data editing steps in the current study followed the same increasing trend (Fig. 1), which could indicate improvement in calf disease recording is currently still ongoing in Ontario. Indeed, the data loss due to herds not having two consecutive years' worth of data records or a disease prevalence of <1% among those herds that provided calf health data, which were the quality control checks used in the current study, appeared to decrease over time (from 30% in 2009 to 24% in 2020). Standardized definitions, user-friendly recording systems, and training of employees to ensure reliable diagnosis of calves may lead to increased or improved recording on farms already recording leading to high-quality data. With enough data, it becomes possible to identify sires based on estimated breeding values with an increased or decreased proportion of affected daughters (Barkema et al. 2015; Pryce et al. 2016) as done for, e.g., hoof health traits (Malchiodi et al. 2017) or fertility disorders (Guarini et al. 2019). The creation of selection indexes that encompass novel traits such as calf disease traits can improve accuracy of selection, which ultimately allows breeding programs to make genetic progress in all traits (Miglior et al. 2016, 2017).

Case study on calf disease recording practices in Ontario farms

The survey on calf health recording practices was distributed to 13 dairy producers and all surveys were completed (100%). The subset of producers who responded to the survey were all part of the larger DHI database previously mentioned. The surveys were completed predominantly by the farm owner (85%) with the remainder of the surveys completed by the herd manager (15%). The average herd size was 429 (range 106–1041), which is higher than the average herd size of 75–95 cows per farm in Ontario (Dairy Farmers of Canada 2021*b*). Most calves were born in group pens (84.6%) and the rest in individual calving pens (15.4%). Close to a quarter of producers in the current survey indicated that they weighed the calves at birth (23.1%). All calves were provided with colostrum within 5 h after birth with 61.5% of producers indicating that they tested the quality of the colostrum. After 24 h, the calves were kept in individual hutches/pens (23.1%), in individual pens followed by group pens (53.8%), or in group pens (23.1%). More details of calf management are provided in Hyland (2022) but were considered out of the scope of the current study.

On-farm diagnosis of respiratory illness and diarrhea

The most frequent indicators used for respiratory illness included coughing, followed by nasal discharge, alertness, and rectal temperature (Table 2). The most common signs used to diagnose diarrhea were, in descending order, alertness, fecal score, and rectal temperature (Table 2). These results are in line with a recent study showing indicators used by Canadian producers when deciding to use antimicrobials (Uyama et al. 2022). In particular, for diarrhea treatment, producers considered fecal score (75%), alertness (60%), fever (59%), level of de-

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Table 2. Indicator and severity thresholds used when diagnosing calf disease conditions (respiratory illness and diarrhea) by 13 dairy producers in Ontario.

	Respiratory illness		Diarrhea	
	n	%	*n*	%
Do you use RECTAL TEMPERATURE as an indicator for the condition?				
No	3	23.1	10	76.9
Yes	10	76.9	3	23.1
Do you use COUGHING as an indicator for the condition?				
No	0	0	NA	NA
Yes	13	100	NA	NA
Normal (no cough)	1	7.7	NA	NA
Slight cough	3	23.1	NA	NA
Moderate cough	8	61.5	NA	NA
Very frequent cough	1	7.7	NA	NA
Chronic cough	0	0	NA	NA
Do you use NASAL DISCHARGE as an indicator for the condition?				
No	1	7.7	NA	NA
Yes	12	92.3	NA	NA
Normal with no discharge	0	0	NA	NA
Constant running nose	4	33.3	NA	NA
Cloudy discharge	8	66.7	NA	NA
Opaque discharge	0	0	NA	NA
Do you use ALERTNESS as an indicator for the condition?				
No	1	7.7	0	0
Yes	12	92.3	13	100
Normal disposition, alert, eyes attentive, ears normal	0	0	0	0
Slightly off disposition, ears down	10	83.3	9	69.2
Moderately depressed disposition, head and ears down, dull eyes, lethargy	2	16.7	3	23.1
Very depressed disposition, head and ears down, dull eyes, will not get up	0	0	1	7.7
Severely depressed disposition, lateral recumbent	0	0	0	0
Do you use FECAL SCORE as an indicator for the condition?				
No	NA	NA	2	15.4
Yes	NA	NA	11	84.6
Normal stool	NA	NA	0	0
Soft to loose stool	NA	NA	6	54.5
Stool is loose to watery	NA	NA	5	45.5
Stool is watery, discolored, may have blood	NA	NA	0	0
Stool is watery, clear, has blood	NA	NA	0	0
Treatment provided upon diagnosis[a]				
Antibiotics	13	100	6	46.2
Pain relief medication	8	61.5	6	46.2
Anti-inflammatories	9	69.2	9	69.2
Electrolytes	0	0	6	46.2

[a]Producers could select multiple options.

hydration (51%), and other signs (24%), while for respiratory disease treatment, producers considered elevated breathing rate (76%), fever (65%), coughing (62%), nasal or ocular discharge (41%), and other signs (27%, which included alertness) (Uyama et al. 2022).

Rectal temperature was the least frequently used indicator, especially for diarrhea. Although a high temperature is not indicative of calf diarrhea, it may be an early identifier of a systemic problem or secondary infection (Constable 2004). However, temperature measurements require more effort (equipment, animal handling) compared to the other behavioral/observational indicators, which could explain their less frequent use. Furthermore, the accuracy of temperature readings also depends on the equipment and technique of measurement used (Naylor et al. 2012). Interestingly, not all producers used fecal score as an indicator of diarrhea despite it being its most direct indicator. The use of fecal scores and detection rates helps inform treatment plans (McGuirk 2008), but detection is not always optimal for identifying individual animals or if extreme watery stool shifts through bedding/slats or if the pen is dirty.

For both diseases, the majority of producers selected the same threshold of each indicator (Table 2) and included an average rectal temperature of 39.5 °C (range 39.0–40.0 °C) from which point a calf was considered to be sick. These thresholds generally tended to be on the less severe end of the scale (Table 2), suggesting possible early detection of illness, which is beneficial for improved health management (McGuirk 2008; McGuirk and Peek 2014). The largest spread of thresholds was found for coughing as an indicator of respiratory illness (Table 2), going from a slight to moderate to very frequent cough. While there was no sole threshold that was the same for all producers, in general, thresholds were closely related (e.g., slowly increasing severity but no extremes being selected by different producers). This suggests that there is some subjective difference as to when a disease is recorded. Producers are suggested to diagnose cases with relatively low sensitivity but high specificity (Sivula et al. 1996). Compared to an experienced veterinarian as a reference standard, Knauer et al. (2017) reported that producers could identify the health status (sick or healthy) of group-housed calves with a sensitivity of 26% and a specificity of 97%. The sensitivity and specificity of the Wisconsin calf respiratory scoring chart to diagnose bovine respiratory disease was previously estimated at 62.4% and 74.1%, respectively (Buczinski et al. 2015). Fecal scores can also accurately predict diarrhea or indicate a decrease in fecal dry matter (Renaud et al. 2020). Furthermore, fecal scores can be assessed with a high intrarater reliability, though few studies have reported on intra- or inter-reliability (Renaud et al. 2020). Different levels of agreement between producers, technicians, and veterinarians are also reported, which can improve when less categories are used (Berman et al. 2021). Love et al. (2014) proposed a system with dichotomized scores for coughing, nasal discharge, ocular discharge, ear and head carriage, fever, and respiratory quality, which correctly classified 89.4% of bovine respiratory disease cases and 90.8% of controls. Thus, a dichotomized scale may be sophisticated enough for gaining initial reliable calf disease records for genetic evaluation; promotion of this simplified scale may increase the recording in Canadian dairy herds.

Most producers reported that they used three indicators (53.9%), followed by all four indicators (38.4%), and two indicators (7.7%) when determining whether a calf has respiratory illness. Uyama et al. (2022) similarly reported that over half of the producers used at least three signs to make decisions on antimicrobial usage for respiratory disease in calves. In the current study, the calf's alertness and general disposition were always used in conjunction with other indicators for respiratory illness. This alertness and general disposition received a relatively high importance such that this one indicator would be enough to classify calves with respiratory disease (Love et al. 2014). Interestingly, calf alertness and general disposition were used by all farms to aid in the diagnosis of diarrhea, and, in fact, two farms stated that this was the only indicator they used (15.4%). The remaining producers used a combination of two (61.5%) or three (23.1%) of the indicators provided for diarrhea. Others found that 18% of producers used all diarrhea-specific indicators of fecal score, alertness, level of dehydration, and fever; over 80% used systemic signs (fever, alertness, bloody stool, veterinarian recommendation, no response to previous treatment, etc.) when deciding on antimicrobial treatments for diarrhea (Uyama et al. 2022). Recommendations from veterinarians highlight the importance of looking at the disposition and eyes of a calf for early detection of diarrhea as a lack of vigor and sunken eyes are signs of dehydration (Smith 2009). Out of all three indicators for diarrhea used in the current study, alertness is the one that is most easily observed on individual calves with little effort.

The use of multiple indicators for both diseases is the most probable method used by producers to aid in the diagnosis of calf disease events, which can help inform disease treatment (Uyama et al. 2022). It should be noted that this describes producer diagnosis of calf diseases as opposed to veterinarian diagnosis. However, producers likely consult with their veterinarians and 45% of producers previously reported that their veterinarian reviewed disease occurrence at least once per year in their herd (Denis-Robichaud et al. 2019). These types of data may not provide the full picture as to causative agents of disease as compared to when proper veterinary or laboratory diagnosis is performed. However, this granularity may not be necessary from a genetic point of view because with a standardized phenotype where the outcome is sick or healthy, genetic evaluations may improve calf health regardless of the causative agent (e.g., all forms of respiratory illness or diarrhea are targeted). Clear case definitions may also help increase the amount of data recorded despite potentially reducing the accuracy of the diagnosis (Kelton et al. 1998), and the development of common standards to define cases for treatment with antimicrobials have been recommended (Uyama et al. 2022). This recommendation also holds true for the recording of calf diseases for breeding purposes, though case definitions may be less stringent than those for prudent antimicrobial usage.

Recording of calf diseases

One aspect of the survey aimed to understand what traits related to calf health are recorded, through which platforms, and with what details (Table 3). Both computer-based and paper-based records were used when keeping calf disease records. Calf mortality (92.3%), respiratory illness (76.9%), and diarrhea (61.5%) were recorded in a computer-based system by the majority of the producers, while some indicated that they used a paper-based system only (Table 3). The majority of farmers using computer-based records provides promise for the development of a data pipeline, from farm through DHI to Lactanet (Miglior et al. 2016), which in turn will help to reduce data loss due to transcribing (Fig. 2).

In Canada, calf mortality must be recorded to comply with ProAction Traceability requirements, but the recording of calf respiratory illness and diarrhea per se is not included (Dairy Farmers of Canada 2020). However, recording calf diseases is beneficial for the early identification of issues, to help prevent disease outbreaks and retroactively help producers and their veterinarians deal with a disease outbreak (Smith 2012). This subset of producers was surveyed because they

Table 3. Recording system used for recording calf health (respiratory illness, diarrhea, and calf mortality within 48 h) including additional information captured in computer-based or paper-based recording systems on 13 Ontario dairy farms.

	Respiratory illness		Diarrhea		Calf mortality	
	n	%	*n*	%	*n*	%
Recording system						
No recording	0	0	1	7.7	0	0
Paper records only	3	23.1	4	30.8	1	7.7
Computer records only	3	23.1	2	15.4	7	53.8
Paper and computer records	7	53.8	6	46.2	5	38.5
Do you record any of the following?						
If using computer-based recording[a]						
Signs of illness	0	0	0	0	NA	NA
Treatment	10	100	8	100	NA	NA
Cause of death	NA	NA	NA	NA	12	100
If using paper-based recording[b]						
Signs of illness	4	40.0	3	30.0	NA	NA
Treatment	9	90.0	9	90.0	NA	NA
Cause of death	NA	NA	NA	NA	5	83.3

[a]Percentage expressed out of the total number of producers with computer records for each trait (respiratory illness $n = 10$, diarrhea $n = 8$, and mortality $n = 13$).
[b]Percentage expressed out of the total number of producers with paper records for each trait (respiratory illness $n = 10$, diarrhea $n = 10$, and mortality $n = 6$).

were known to keep high quality records, but it is interesting to note that while all recorded calf mortality and respiratory disease, one farm did not record diarrhea. In a 2014 Canadian Dairy Study, calf diarrhea was ranked as the third priority and respiratory disease as the fifth priority by producers (Bauman et al. 2016). This ranking was likely done from a management perspective with producers eager to address calf diarrhea, but this does not necessarily translate to increased efforts or awareness of the importance of record keeping. For both recording types, most indicated that producers (computer: 75.0% and paper: 61.5%) and herd managers (computer: 66.7% and paper: 69.2%) entered the data, while general farm employees less commonly entered the data (computer: 25.0% and paper: 30.1%). Wilson et al. (2021) indicated that some producers found it hard to obtain well-trained employees that were equipped to deal with calves and their care. A standard operating procedure that includes identification of sick calves, how and where this information needs to be recorded, as well as proper training of personnel may lead to increased and more accurate recording.

Producers that used computer-based systems all provided information on the treatment of respiratory illness and diarrhea, likely due to the treatment protocol function available in these systems that is motivated by wanting to track antimicrobial usage. In contrast, there is often no default designated space that allows reporting of the signs of illness in the computer-based system, and farmers with these systems in the current study did not record details on the signs of illness. In contrast, some producers that used paper-based systems reported signs of illness, while one producer did not appear to record treatments for both respiratory illness and diarrhea. Recording the signs of an illness can be valuable in proper and timely diagnosis (McGuirk 2008; Smith 2012; McGuirk and Peek 2014) but can be inconsistent. A large study in Nordic countries also identified inconsistency in the reporting of signs by producers despite instructions to do so, with 25% of recording sheets being provided with information about observed signs (Espetvedt et al. 2012). While treatment information can be valuable, it should not be the focus as this may either over- or under-report diseases compared to diagnosis depending on whether multiple treatments are required for a single case, treatments are applied preventatively, or if a case does not receive any treatment (Kelton et al. 1998).

Most farms selected the same computer-based codes when recording respiratory illness on the computer (90% PNEU and 10% RESP). When recording diarrhea however, there was a split between codes used (50.0% DIAR and 37.5% SCOURS), with one farm using a nonspecific treatment code (12.5% TX) in favor of the “DIAR” or “SCOURS” code available within the software. The discrepancy between disease codes used by the producers in this study is likely due to the interchangeable use of the terms respiratory illness and pneumonia and diarrhea and scours by most industry members. Additionally, some producers (30%) also used shorthand notations or multiple languages in the paper-based records to capture more details. The computer-based codes are pre-set in the software and fairly standard; however, producers are also able to adapt and provide their own codes as part of the build-in flexibility of computer software for on-farm management purposes. However, this flexibility can lead to different codes indicating the same condition or protocols (Kelton et al. 1998; Wenz and Giebel 2012; Lynch et al. 2021). Awareness that these different codes are used in on-farm recording is important as this may require machine learning methods to combine codes or may otherwise influence genetic evaluations as demonstrated for fertility traits (Lynch et al. 2021; Alcantara et al. 2022). Gonzalez-Peña et al. (2019) similarly reported the need to combine "RESP" and "PNEU" records for genetic evaluations of calf wellness traits in the United States. The creation of a data dictionary that visualizes the multiple codes that describe the same disease event and combines these in a single corresponding trait code could also be useful.

As mentioned previously, it is currently a requirement to record calf mortality (Dairy Farmers of Canada 2020). Still births are currently already used in genetic evaluations in Canada (Luo et al. 1999; Oliveira Junior et al. 2021) and are defined as animals that died within 24 h of birth. Previous estimates for still births in Canada average 4.9%, but pre-weaning calf mortality was also reported by 54% of producers at an average rate of 6.4% (Winder et al. 2018), suggesting that pre-weaning mortality may be worth addressing through genetic evaluation. The cause of death was recorded if known by all (computer-based) or nearly all (83.3% paper-based) producers, which may provide valuable details. However, determining the cause of mortality may be difficult in practice. The sensitivity of producer diagnosis of enteritis and pneumonia as the cause of calf mortality was approximately 56%–58%, while specificity was much higher at 93%–100% (Sivula et al. 1996). This suggests that producers may under-report specific causes of mortalities, which could indicate that generic pre-weaning calving mortality regardless of the cause may be more likely to be addressed through genetic evaluations.

It should be acknowledged that this study only considered herds in Ontario that were enrolled in DHI who already kept records on calf disease to better understand current recording practices. As such, the results reported in the current study should be interpreted with caution and not generalized to all dairy producers in Canada. This holds particularly true for the survey aspect of this study, which included a small sample of producers in Ontario. Additionally, it would be interesting to investigate the attitudes and barriers in those producers who currently do not record calf disease. However, insights gleaned from this research may aid in the development of knowledge mobilization strategies within the industry to improve calf health on Canadian farms.

Conclusions

This study is among the first to evaluate the current state of calf disease recording for genetic evaluations in Canada. Current data suggest that an increasing number of farms are recording calf disease events (i.e., respiratory illness and diarrhea). However, to use this information for calf health genetic evaluations, potential data loss that can occur at different stages on-farm or during transfer between data sources needs to be addressed to improve the data pipeline from farm through DHI to Lactanet. Main recommendations include standardized case definitions for calf respiratory illness and calf diarrhea based on multiple indicators on a dichotomized scale to capture calf disease according to a common standard on Canadian dairy farms. Additionally, standard operating protocols for recording and data exchange are needed to decrease the possibility of data loss during the transfer of data. Together, these improvements should assist with consistent recording of calf disease needed to start including calf health traits in genetic evaluations.

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Data availability

Data on the number of milking herds and milking herds on dairy herd improvement (DHI) are publicly available from Agriculture and Agri-Food Canada (https://agriculture.canada.ca/en). Data regarding calf health from DHI herds are confidential. Data generated or analyzed from the survey conducted in this study are provided within the published article in aggregated form.

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Competing interests

F. Miglior is an employee of Lactanet Canada. The remaining authors declare no conflict of interest.

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