Evaluating calf health recording and incidence of respiratory disease and diarrhea on Ontario dairy farms using producer recorded data

by

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ABSTRACT

EVALUATING CALF HEALTH RECORDING AND INCIDENCE OF RESPIRATORY DISEASE AND DIARRHEA ON ONTARIO DAIRY FARMS USING PRODUCER RECORDED DATA

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Research into the genetic aspects of calf health traits is an emerging field for the dairy industry. Calf respiratory illness and diarrhea remain the two highest causes of calf morbidity and mortality in Canada and worldwide. Previous research has shown there are long term effects to an animal as a result of calfhood morbidity. The goal of the research described in this thesis was to understand the quantity and quality of calf health information available, specifically respiratory illness and diarrhea, that could be used in future genetic research. The results indicate that there are low levels of accessible calf health information in comparison to cow health information, and inconsistencies in how information was recorded between farms. This work substantiates previous concerns that there is little standardization in how calf diseases are being recorded on farms. Modified use of current recording methods may improve the amount of calf data accessible.

DEDICATION

To my Oma and Opa, I wish you could have seen what we have all accomplished and to my Grandma and Grandpa for being my biggest supporters since day one.

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1 General Introduction

The Canadian dairy industry is one of the largest agriculture sectors in the country (CDIC, 2021). The production and selling of milk, however, is not the only part of the industry with economic value. The dairy genetics industry is also important, domestically improving the production and health of Canadian animals, and as an international exporter of genetic material (CDIC, 2021). The incorporation of genetics and genomics has helped improve production in Canadian livestock and more recently has allowed researchers to investigate the genetic aspects of health and welfare. Voluntary on-farm health recording of key diseases that afflict dairy cows on Canadian farms is typically done from a management or regulatory perspective but can also positively contribute to the genetics industry. The recording of mastitis, metritis, retained placentas, cystic ovaries, left displaced abomasums, milk fever, ketosis, and lameness on farm introduced the idea that on-farm recorded health data could be used for more than just health management of the herd, but also genetic evaluations, which had previously been done in other countries (Kelton et al., 1998; Koeck et al. 2012). In Scandinavian countries, where veterinary recording of health data is required, these low heritability traits showed favourable additive genetic variation despite their low heritability (Philipsson and Lindhé, 2003). The expansion of genetics and genomics further has led to novel traits being investigated such as hoof health, feed efficiency, and methane emissions (Miglior et al., 2017). In additional to the ability to investigate novel traits, breeding for resiliency has become a priority for the future success of the Canadian dairy industry. To achieve this goal, more research was proposed to continue the development and classifications of standardized recording practices for currently unrecorded health traits, namely those related to calves.

Dairy farms in Canada breed animals to produce calves that will eventually replace the milking herd, with each generation hopefully marking an improvement in the herd's overall production, fertility, and health. Research has indicated that a disease event in a calf can have long-term effects on their health and production (Svensson and Hultgren, 2008; Heinrichs and Heinrichs, 2011). Calf respiratory illness and calf diarrhea are of the highest concern because of their high incidence and due to the short and long-term effects they have on a calf's health, including the increased risk of mortality (Gulliksen et al., 2009). With the negative short- and long-term implications of calf illness, it has been proposed that calf health events be investigated for inclusion into the national genetic evaluation system. One of the most important considerations for genetic evaluations is that phenotypes are well defined and accurate. Therefore, it is important to understand what and how calf health events (e.g., respiratory illness and diarrhea) are recorded to determine the current state of available phenotypic data. Additionally, as health traits are multifaceted, it is important to consider on-farm calf management practices and decisions to provide context for the on-farm recording practices.

1.1 Respiratory Illness

Respiratory illness in calves is both economically important and reduces calf welfare (Stanton et al., 2012; Closs and Dechow, 2017). Because of its importance to the dairy industry, it has been studied thoroughly in both Canada and the world. Management decisions are a major factor when it comes to the risk of respiratory disease in calves. Daily cleaning of feeding equipment, good ventilation and temperature control, and providing clean and dry pens to calves can help reduce risk of respiratory disease (Louie et al., 2018; Medrano-Galarza et al., 2018). Season of birth can influence the likelihood of a calf getting respiratory illnesses as reported by Closs and Dechow in 2017, with calves born in the fall and winter having more treatments recorded than the other two seasons. Furthermore, experiencing a case of respiratory disease can lead to early exit from the herd (Stanton et al., 2012; Closs and Dechow, 2017). Due to the risk of death or culling before an animal enters the milking herd, the long-term effects of respiratory illness may not be fully realized (Stanton et al., 2012). Respiratory illness is an umbrella term for various closely related illnesses, meaning there are multiple pathogens that can cause the disease. Regardless of cause, viral or bacterial, antibiotics are frequently used to treat respiratory illness in dairy calves (Short and Lombard, 2020). With the rise of antibiotic resistant bacteria and the risk that poses to human medicine, indiscriminate antibiotic use in livestock production is a common concern among industry stakeholders (Barkema et al., 2015; Bauman et al., 2016). Management alone cannot eliminate respiratory illness completely, but prevention is commonly thought to be the best course of action for most diseases.

1.2 Diarrhea

Calf diarrhea is a common pre-weaning disease and is responsible for a majority of pre-weaning mortality in dairy calves (USDA, 2014). It most commonly affects calves early in life, with a calf being susceptible to different bacteria and viruses at different ages. *Escherichia coli* usually affects calves within the first four days while the other most common causes, rotavirus, coronavirus, and *Cryptosporidium* parvum affect calves between one and three weeks old (Meganck et al., 2014). The most common treatment for calf diarrhea is electrolyte fluids to treat dehydration and ultimately prevent the death of the calf. Oral electrolyte solutions are recommended to be administered to calves diagnosed with diarrhea until the animal recovers and intravenous fluid therapy is recommended for cases where severe dehydration is already present (Meganck et al., 2014). Use of antibiotics occurs but is not as common due to the rise in antimicrobial resistance and the need to know the causative bacteria to treat (Meganck et al. 2014), this is in contrast to respiratory illness where antibiotics are used as a primary treatment regardless of causative pathogen (Short and Lombard, 2020). Like respiratory illness, management plays an important role in whether or not a calf will get diarrhea. Calves often contract diarrhea via fecal-oral transmission which can be prevented at various stages of the pre-weaning period. Early removal from the dam and other adult animals can help reduce this risk (Medrano-Galarza et al., 2018). Further prevention can be achieved by consistent cleaning of high traffic surfaces such as feeding equipment, especially automatic feeders in group pens (Medrano-Galarza et al., 2018). Full cleaning of bedding, not just adding dry bedding to soiled pens, can also reduce risk of calf diarrhea (Medrano-Galarza et al., 2018). As with respiratory illness, prevention of disease through good management practices is the best course of action when it comes to reducing incidence of calf diarrhea on farm.

1.3 Genetic Evaluations and Requirements of Phenotypes

Using genetic selection to improve health in the dairy industry is an on-going endeavour. Even traits with low heritability are successfully selected for over time, especially those with genetically favourable correlations with other important traits (Guarini et al., 2019). Selection for calf traits has not been implemented at a large scale but has been the subject of previous research (Henderson et al., 2011a; Gonzalez-Peña et al., 2019). Some of the earliest modern genetic research involving calf health investigated bovine respiratory disease in beef cattle (Muggli-Cockett et al., 1992; Snowder et al., 2005). In dairy calves, early research in Norway yielded heritability estimates of 5% for respiratory disease, however it should be noted herd sizes in Norway were small and infectious bovine rhinotracheitis was not present in the Norwegian Red population at the time (Heringstad et al., 2008). In the dual-purpose Austrian Fleckvieh cattle, estimates for calf diarrhea and respiratory disease were similarly low (Fuerst-Waltl et al., 2010). Research by Henderson et al. (2011a) found negative and positive correlations, some significant, between calf respiratory illness and various cow confirmation and reproduction traits already being selected for in Canada and the United States. Correlations between the traits need to be taken into consideration when integrating calf health into any future index. There have also been differences in genetic variances between sires for calf survivability traits in dairy populations (Henderson et al., 2011b). Recent work by Gonzalez-Peña et al. 2021 showed heritability estimates for calf diarrhea, respiratory illness and mortality at 0.04, 0.04, and 0.06, respectively. Furthermore, genome wide association studies into passive immunity and disease traits for both dairy and beef calves yielded low to moderate heritability estimates depending on the specific trait (Johnston et al., 2020). In summary, these findings show that there is a heritable component to calf health traits such as respiratory illness and diarrhea which suggests a potential for genetic selection when phenotypes are available.

The aforementioned studies, in particular those in Scandinavia and Austria benefitted from national health monitoring systems that were in place, with veterinary records used as the primary source of disease phenotypes for calves, as opposed to on farm records (Heringstad et al., 2008; Fuerst-Waltl et al., 2010). In Canada, farms can participate in milk recording through Dairy Herd Improvement (DHI) programs, multi-component systems that involve routine milk recording and record keeping. These records include on-farm recording by producers themselves and not veterinary records. This system allows producers to record events they consider important for management of their herd, but it is unclear how commonly calf health events are currently being recorded on Canadian dairy farms. At the moment, there are no standardized criteria for producers to record calf disease in the on-farm system, nor are there definitive requirements in place for recording of calf disease. Previous research focused on the recording system DairyComp305 (Valley Agricultural Software, Tulare, CA), found a lack of standardization of recording between and within farms for important cow illnesses, even those with previously proposed recording guidelines (Kelton et al., 1998; Wenz and Giebel, 2012). All of these aspects result in a potential lack of sufficient and uniform calf health records that would be required for large scale genetic evaluation in Canada.

1.4 Objectives

Therefore, **the objectives of the work described in the current thesis were to:**

1. Provide an overview of current calf health recording practices in Ontario.
2. Understand feasibility of a data pipeline from Canadian farms to the genetic evaluation centre at Lactanet.
3. Develop the foundation for a standard calf health recording system in Canada.

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2 Understanding incidence rates and on-farm recording protocols for calf respiratory illness and diarrhea in Ontario

2.1 Abstract

Calf diseases remain a problem for the dairy industry, from both an economic and welfare perspective. The prospect of genetically selecting for disease resistance in calves is a novel field of research emerging in various dairy producing countries. Genetic evaluations, however, require well-defined and consistently recorded phenotypes to be successful. The amount of calf disease information recorded on farms in Canada has not previously been quantified. Therefore, to implement any genetic evaluations regarding calf disease, specific phenotypes must first be established and verified. A total of 20,501 Canadian Holstein calf disease records for respiratory illness and diarrhea from Ontario farms were used to determine incidence of disease from 2009 to 2020. The incidence for both diseases changed over the decade with respiratory illness remaining more stable over time. The number of farms recording each year also varied, with up to 15% of farms recording calf respiratory illness and/or calf diarrhea in a given year. A survey was provided to thirteen Ontario farms regarding their on-farm recording practices. Survey results indicated differences between how the same disease is recorded on different farms. Standardization of recording for calf diseases needs to occur across Canada as well as sufficient transfer of health data from on-farm records to already available and utilized health recording systems.

2.2 Introduction

Calf health has become an important area of research in recent years. Research has shown that there can be long-term effects to an animal's health and production as a result of early life management and illness (Svensson and Hultgren, 2008; Hultgren and Svensson, 2009; Heinrichs and Heinrichs, 2011). The overall health of a calf is determined by many factors including housing, nutrition, vaccinations, and overall management on the farm. Previous studies have investigated heifer and bull calf management on Canadian farms, including calving management, feeding protocols, colostrum management, pain management, and weaning (Vasseur et al., 2010; Winder et al., 2018; Wilson et al., 2021). A 2016 article published by Bauman et. al indicated calf diarrhea was ranked within the top five disease priorities for industry stakeholders, including producers, veterinarians, universities, government, and others. Respiratory illness was listed as a priority, however, it was not ranked in the top five for parties surveyed at that time (Bauman et al., 2016). Research in Ireland yielded similar results, with dairy and beef farmers indicating calf illness due to diarrhea and respiratory illness to be a high priority (More et al., 2010; Bauman et al., 2016). However, even with stakeholders agreeing these are high priority issues, a comprehensive analysis of the incidence of disease is difficult to conduct with Canadian literature lacking current rates. The most recent national data stems from over a decade ago but at that time, 53% of calf mortality was because of diarrhea and 21% of calf mortality was because of respiratory illness, with the rate of mortality between 7.8-11% (Murray, 2011). In 2014, Windeyer et al. found mortality rate of 3.5% on a subset of Ontario and Minnesota dairy farms, with individual herd mortality values ranging between 0 and 10%. A 2021 study done by Tora et al. in Ethiopia found a morbidity rate of 8.6% among their 196 calves in a longitudinal study.

The most recent code of practice for the care and handling of dairy cattle recommends detailed and accurate health records be kept for animals on-farm (NFACC, 2009); although the code of practice is being updated, there are currently no explicit guidelines for calf health recording described (NFACC, 2009). Benefits of keeping health records are not limited to on-farm management, they can be beneficial at an industry level as well. Voluntary health recording of eight common cow diseases (mastitis, displaced abomasum, ketosis, milk fever, retained placenta, metritis, cystic ovaries, and lameness) in Canada has enabled estimation of genetic parameters and breeding values for these traits using producer recorded data (Kelton et al., 1998; Koeck et al., 2012). Similar goals have been proposed for calf health traits as part of a large scale applied research project aiming to develop an overall resiliency index for genetic selection in Canadian dairy cattle (Baes et al., 2021; van Staaveren et al., 2021). However, this requires understanding how calf diseases are being managed on-farm, including diagnosis and recording, to provide accurate phenotypes.

The objectives of this study were to: 1) Determine the incidence rate of respiratory illness and diarrhea on Ontario dairy farms from producer recorded data, and 2) Determine the management practices performed on Ontario dairy farms with an emphasis on health management and disease recording protocols.

2.3 Materials and Methods

2.3.1 Animal Care and Research Ethics

No Animal Care Committee approval was necessary for the purposes of this study, all information required was obtained from pre-existing databases. The survey conducted in this study received exemption of University of Guelph Research Ethics Board as the focus of the research was exclusively on the animals and the farmer engagement did not require human ethics approval.

2.3.2 Data

Calf health data recorded by dairy producers through management software was provided by Lactanet (Guelph, Ontario, Canada). It comprised 36,392 Canadian Holstein calf disease records for respiratory illness and diarrhea, collected in 538 dairy herds in Ontario, Canada 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 in each herd. This was calculated using number of disease events in a herd per year over the total number of heifer calves raised on that farm in a given year. Additionally, herds had to have consecutive calf health records for years leading to and including 2020, or a minimum of 5 consecutive years of data available if there were no records in 2020. These metrics provided insight to which herds were consistently collecting calf disease information and whom most likely have consistent recording practices.

2.3.3 Annual Disease Incidence

The disease incidence was calculated for every year from 2009 to 2020. The following calculation was performed for both respiratory illness and diarrhea, respectively, for each represented year:

$$Disease\ Incidence = \frac{\#\ of\ calves\ sick\ in\ a\ given\ year\ with\ disease}{\#\ of\ at-risk\ heifer\ calves\ in\ Ontario\ in\ a\ given\ year} \times\ 100\%$$

Where any heifer born in a given year was considered at risk for the first six months (180 days) of her life.

2.3.4 Survey Design

A survey was developed to collect information about calf management and health recording practices occurring on a sub-set of Ontario dairy farms. These farms were already participating in a Canadian Dairy Network for Antimicrobial Stewardship study that aimed to investigate antimicrobial use on Canadian dairy farms (Fonseca et al., Under Review). Dairy Research Cluster 3, 2021). The survey consisted of 63 questions concerning the housing, nutrition, and health of pre-weaned dairy calves on-farm based on contemporary literature in each discipline (McGuirk, 2008; Vasseur et al., 2010). The first twelve questions were based on the diagnoses of calf respiratory illness on farm and how calves were managed upon diagnosis; similar questions were also asked regarding the management of diarrhea on the farms. The largest part of the survey consisted of 42 questions involving disease diagnosis, management, and recording on-farm, with focus on respiratory illness and diarrhea. Several questions related to the identification of health events by farmers 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). For both major illnesses and mortality, farmers were also asked how diseases were recorded on farm in both computer software and in written records. This included asking what pre-set codes were utilized by each producer. Options for respiratory illness were "RESP" and "PNEU" as well as an "Other" option where they could then indicate a different code. The pre-set codes for diarrhea were "DIAR" and "SCOURS" with a third option available as well. Finally, the survey included questions on protocols within 24 hours of calving, with a heavy emphasis on colostrum feeding and management, as well as pre-weaning feeding and housing management. Most of the survey questions were categorical with instruction whether only one or multiple answers could be selected. Some questions had open ended answers including questions about specific drugs utilized for treatment and questions involving paper records without pre-determined codes and options available. The survey was provided in English to a convenience sample of farmers in Southwestern Ontario that participated in the previously mentioned antimicrobial stewardship study and were known to have good on-farm recording practices. Selection of farms was based on results of a short intake survey, which asked farmers if they recorded calf health events on farm. To be eligible, farms had to be enrolled in Dairy Herd Improvement (DHI), a milk recording and data management service offered by Lactanet, that allowed records to be pulled directly from farms. Farmers had to be recording calf respiratory illness and calf diarrhea within on farm recording systems, allowing identification of current recording practices and potential gaps that which need to be addressed to use calf health records for genetic purposes.

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 Development Team, 2020). Full survey results are available in Appendix I.

2.4 Results and Discussion

2.4.1 Calf Health Incidence

Little information is available on the number of farms that keep calf health records in general. The percentage of farms in Ontario with accessible calf disease records via DHI showed a general increase from 2009 to 2020 from approx. 5 to 15% (Table 1). Dutil et al. (1999) reported that 70-85% of farmers kept records in a survey of 520 cow-calf farmers in Quebec. While these percentages for recording are much higher than those in the current study, it should be noted that the Dutil et al. (1999) study related to more general record keeping (e.g., weight or age of calves/cows). Furthermore, calf health was not specifically addressed in Dutil et al. (1999), and values were self-reported, as opposed to a tally of actual farms with records observed in a database as in the current study.

The incidence of respiratory illness and diarrhea varied across years where data were available (Table 1). The greatest incidence of recorded respiratory illness was in 2013 with a province-wide incidence of 25% based on records from DHI enrolled farms, 10% of Ontario farms were recording calf diseases through DHI at the time. The year with the greatest incidence of diarrhea (20.03%) was in 2020 with 13% of Ontario farms recording calf diseases through DHI at the time. These values however may be lower than what occurs on farms as calves are sometimes recorded in a treatment category and not under a specific disease code in the computer system. For both calculations, there were only respiratory illness and diarrhea records available, none for pneumonia or scours, this may represent some loss of data. Definitive incidence rates are not common in literature, but Waltner-Toews et al. (1986) followed a group of heifers born in Southwestern Ontario between 1980 and 1983; 15% of the animals born in that time period were treated for respiratory illness and 20% were treated for diarrhea. More recently, Medrano-Galarza et al. (2018) reported within-pen prevalence of 17% for diarrhea and 11% for respiratory illness in Ontario farms, it should be noted however that prevalence and incidence cannot be directly compared. Previous Canada wide estimates of calf loss indicated up to 11% of calves dying before weaning with 21% due to respiratory illness and 53% due to diarrhea (Murray, 2011). In the United

States, similar results were found with over 50% of pre-weaning death due to diarrhea, and almost 25% due to respiratory illness (USDA, 2021).

Overall, incidence rates for respiratory illness (approx. 24 to 18%) and diarrhea (approx. 11 to 20%) varied slightly between years. In 2020 however, the incidence of respiratory illness was at its lowest at 18%, this could be explained by increased efforts or improvements in managing calf respiratory illness (Gorden and Plummer, 2010). In contrast, diarrhea is highly multifactorial and can be attributed to multiple pathogens and management practices (Naylor, 2009) and may therefore be more difficult to diagnose and manage.

2.4.2 Disease Diagnosis and Management

The survey was distributed to 13 dairy producers and all surveys were completed (100%). The surveys were completed predominantly by the farm owner (85%) with the remainder of surveys completed by the herd manager (15%). The subset of farmers who responded to the survey were all part of the larger incidence calculations previously mentioned. Survey questions included calf management practices on farm with an emphasis on disease diagnosis.

2.4.3 On-Farm Diagnosis of Respiratory Illness

The most frequent indicators used for respiratory illness included coughing, followed by nasal discharge and decreased alertness, and rectal temperature (Table 2). Over two-thirds of all farmers considered a calf to have respiratory illness when they presented with a moderate to very frequent cough, while nearly a quarter of all farmers considered calves to be sick when they had a slight cough. Nasal discharge (cloudy discharge: 66.7%; constant runny nose: 33.3%) was another indicator of respiratory illness. One farmer indicated that a calf could be diagnosed with respiratory illness without coughing when other signs of illness are present such as a high temperature with the animal slightly off for alertness with drooping ears. The calf's alertness and general disposition was generally also considered a useful indicator of illness, with 92% of farmers using alertness and general disposition in combination with other signs of illness. For rectal temperature an average temperature threshold of 39.5 degrees Celsius (°C, range 39.2-40.0°C) was used for diagnosis.

All clinical signs appearing in this section are comparable to those described in the UC Davis bovine respiratory disease scoring system, where any non-induced spontaneous coughing counts towards diagnosis (FAAST, 2021). Nasal discharge, even at low levels of discharge, and a calf's overall vigour and disposition (FAAST, 2021) were heavily weighted when diagnosing respiratory disease. This trend was also observed on most farms in the current study, which implies farmers are aware of early signs of illness. Early detection of illness is beneficial for improved health management, though sensitivity of detection has previously been reported to be approximately 56-58% (Sivula et al., 1996; McGuirk, 2008; McGuirk and Peek, 2014).

2.4.4 On-farm Diagnosis of Diarrhea

The most common signs used to diagnose diarrhea were in order from highest to lowest, alertness, fecal score, and rectal temperature (Table 3). Farms that used rectal temperature as a sign were in the minority, with an average temperature of 39.4°C as the threshold. Although a high temperature is not indicative of calf diarrhea, it may be an early identifier of a systemic problem or secondary infection (Furber, 2017; FAAST, 2021). All farms used alertness to aid in diagnosis of diarrhea. Observation of a calf that was 'slightly off' with their ears down was sufficient for most farmers for diagnosis, followed by moderately depressed calves with dull eyes and head and ears down, and one farm indicated a calf had to be very depressed and would not get up to be diagnosed as ill (Table 3). Recommendations to producers from veterinarians highlight the importance of looking at the disposition and eyes of a calf for early detection of diarrhea (Furber, 2017; Renaud, 2018). Calves that lack vigour and have sunken eyes are most likely afflicted by diarrhea (Furber, 2017; Renaud, 2018; FAAST, 2021). The severity of dehydration can be measured through how sunken a calf's eye is or by pinching the skin, the more dehydrated the animal, the longer the skin will remain tented, this severity should also determine the ideal treatment plan for the calf (Renaud, 2018; FAAST, 2021). Interestingly, not all farms used fecal score as an indicator of diarrhea despite it being its most direct indicator. However, when fecal score was considered, low thresholds of soft to loose stool or loose to watery stool were used to identify diarrhea. The use of fecal scores and detection rates help inform treatment plans (McGuirk, 2008), but detection is not always optimal for example, if extreme watery stool shifts through bedding/slats or if the pen is dirty.

2.4.5 Recording of Disease

Calf mortality, respiratory illness and diarrhea were recorded in a computer system by the majority (92.3%) of the farmers, while some indicated they used a paper-based system only (Table 4). One farm did not record diarrhea at all in either the computer or in a written format. For both recording types, most indicated producers and herd managers were the main people recording information, while general farm employees were only responsible for recording on a few farms. Interestingly, farmers that used computer-based systems all provided information on treatment of respiratory illness and diarrhea, but no signs. In contrast, farmers that used paper-based systems reported signs of illness along with the treatments for both respiratory illness and diarrhea more often. Recording of the signs of illness can be valuable in proper and timely diagnosis (McGuirk, 2008; McGuirk and Peek, 2014; Smith, 2012), however this finding is likely because there is not always a default designated space that allows reporting of the signs of illness in the computer-based system and the remark section is often used for treatment information.

Most farms selected the same computer-based code when recording respiratory illness in the computer, when recording diarrhea however, there was a split between codes used. Additionally, one farm used a non-specific treatment code (TX) in favour of the "DIAR" or "SCOURS" code available within the software. For animals that died within 48 hours of birth, a majority (66.7%) of farms entered the event as a death in the software with the remaining farms entering the event as still birth. All farms with written mortality records wrote that the animal had died and was not a still birth if it died within 48 hours of birth. For both computer records and written records, cause of death was recorded if known by all farmers.

Understanding how health data are recorded on farm is crucial to understanding the status of calf diseases in Ontario. Producer recorded data can be integrated with genetic selection if recording is consistent on farms (Koeck et al., 2012). If the amount of recording happening is low or inconsistent however, farms are more likely to be removed in data validation steps. The benefits of computer recording allow for flexibility in on-farm management but can also result in data loss if the same health event is being recorded differently across farms. Research focused on integrating calf wellness traits into genetic evaluation systems in the United States noted needing to combine "RESP" and "PNEU" records for their evaluation due to different code preferences among farms (Gonzalez-Peña et al., 2019). It is likely similar integration of codes may be needed in cases where "DIAR" and "SCOURS" are available codes based on responses in the current study. In Canada, it is currently a requirement that calf mortality is recorded to comply with ProAction Traceability requirements but recording of calf respiratory illness and diarrhea are not required (Dairy Farmers of Canada, 2020). Further simplification of codes may also be beneficial to the further understanding of recorded incidence of disease in a less specific manner. Using a general code for respiratory illness in pre-weaned calves across platforms such as “RD” or “RESPDIS” could help separate it from cow disease and prevent data loss from multiple codes being used. Similarly, encouraging farms to record diarrhea under a specific code, for example “DIAR”, may help prevent data loss.

Recording of calf disease is directly beneficial to the producer as well. Identification of problems within the herd early can prevent disease outbreaks or retroactively help producers and their veterinarians deal with a disease outbreak (Smith, 2012). While this subset of farmers was selected because they were known to keep (good) records, there was still some inconsistency or lack of recording certain conditions (e.g., 1 farm not recording diarrhea) which could limit its usefulness. From the producer-driven health records provided from Ontario, it appears that only a small proportion of farmers are currently recording diarrhea and respiratory illness in a manner that allows it to be uploaded into a central data repository (approx. 15%). However, the on-farm validations of the ProAction biosecurity module on 2,447 farms between 2019 and 2020 indicated that 83% of farms recorded the occurrence of disease health events for cows and calves. It is unclear how many of these farms have calf health records that could be made available centrally. Addressing the barriers that prevent the uptake of calf health recording in a standardized manner need to be addressed on a Canada-wide scale to be able to incorporate calf health traits into genetic evaluations.

2.5 Conclusion

Using producer-recorded data collected over the past decade, we were able to estimate annual incidence for respiratory illness and diarrhea pre-breeding dairy calves in Ontario. The annual incidence of respiratory illness ranged from 18% - 26% while the annual incidence of diarrhea ranged from 11% - 20% which shows that both conditions remain prevalent on dairy farms with implications for calf health and farm performance. The number of Ontario farms that actively recorded both calf diseases in a system where it could be uploaded centrally is low (approx. 15%) and therefore farmers should be encouraged to incorporate calf health records into their routine DHI recording protocol. More in-depth surveys on recording practices on 13 Ontario farms revealed that, even in a subset of farmers who are considered to keep good records, there is variability in the method of data recording (e.g., computer or paper-based, codes used, threshold for diagnosis). A standardized recording protocol for calf health traits, including clear disease definitions and disease event terms, is needed before being able to consider producer recorded data in genetic evaluation programs that may improve calf health. Research on facilitators and barriers of standardized calf health recording should be undertaken to improve calf health benchmarking which can be beneficial for animal health/welfare, farm management and breeding programs.

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2.8 Tables

Table 2.1: Incidence of respiratory illness and diarrhea on Ontario dairy farms from 2009-2020 on farms with accessible records

Year	Respiratory Illness			Diarrhea			Percent of Ontario Farms with Accessible Records[2]
	Incidence (%)	# of at-risk calves[1]	# of herds with records	Incidence (%)	# of at-risk calves[1]	# of herds with records	(%)
2009	24.18	1977	25	14.52	544	10	5.09
2010	23.85	2176	28	19.47	1109	12	6.80
2011	22.80	2731	39	12.86	1842	24	8.03
2012	23.44	3592	49	14.24	1734	25	8.40
2013	25.69	4071	54	14.10	2184	28	10.01
2014	22.97	5189	66	18.64	2977	34	11.33
2015	24.08	6051	73	19.71	3526	40	10.72
2016	21.77	5783	76	11.16	3172	36	9.33
2017	21.58	6682	79	16.96	3042	38	11.26
2018	22.88	8055	98	12.54	3684	40	14.40
2019	21.59	9439	121	17.64	4603	54	15.61
2020	18.25	9523	134	20.03	4493	62	13.45

[1]Calves at risk were any heifers born during a given year until they were 180 days of age

[2]Farms were considered accessible if they participated in Dairy Herd Improvement records of any calf disease. These values were calculated using the number of herds with accessible records over the total number of Ontario farms each year from 2009-2020, the denominator therefore changed depending on the calculated year.

Table 2.2: Diagnostic parameters and management protocols for calf respiratory illness on thirteen Ontario dairy farms

	Responses	
	n	%
What do you use as an indicator for respiratory illness? (n = 13)		
Rectal temperature	10	76.9
Coughing	13	100.0
Nasal discharge	12	92.3
Alertness (including ear position and eyes)	12	92.3
What cough severity do you consider the threshold for recording respiratory illness? (n=13)		
Normal (No cough)	1	7.7
Slight cough	3	23.1
Moderate cough	8	61.5
Very frequent cough	1	7.7
Chronic Cough	0	0
What nasal discharge do you consider the threshold for recording respiratory illness? (n=12)		
Normal with no discharge	0	0
Constant running nose	4	33.3
Cloudy discharge	8	66.7
Opaque discharge	0	0
What alertness do you consider the threshold for recording respiratory illness? (n=12)		
Normal disposition, alert, eyes attentive, ears normal	0	0
Slightly off disposition, ears down	10	83.3
Moderately depressed disposition, head and ears down, dull eyes, lethargy	2	16.7
Very Depressed disposition, head and ears down, dull eyes, will not get up	0	0
Severely depressed disposition, lateral recumbent	0	0
If a calf is recorded with respiratory illness is it temporarily removed from the pen it is housed[1] (n=13)		
If house in individual pen, remains in the pen	3	23.1
If housed in individual pen, is moved physically away from other pens	2	15.4
If housed in a group, remains with the group	10	76.9
If housed in a group, is moved away from group	0	0
If an animal had respiratory illness, is the pen cleaned? (n=13)		
Pen or hutch is not cleaned	10	76.9
Bedding in the pen or hutch is changed	1	7.7
Pen or hutch is cleaned	1	7.7
Pen or hutch is cleaned and new bedding is added	1	7.7
If a calf has respiratory illness, what treatment is performed?[1] (n=13)		
Antibiotics	13	100
Anti-inflammatories	8	61.5
Pain Relief Medication	9	69.2
Other	0	0

[1]Farmers could select multiple options.

Table 2.3: Diagnostic parameters and management protocols for calf diarrhea on thirteen Ontario dairy farms

	Responses	
	n	%
What do you use as an indicator for diarrhea? (n=13)		
Rectal temperature	3	23.1
Alertness	13	100
Fecal score	11	84.6
What alertness do you consider the threshold for diarrhea? (n=13)		
Normal disposition, alert, eyes attentive, ears normal	0	0
Slightly off disposition, ears down	9	69.2
Moderately depressed disposition, head and ears down, dull eyes, lethargy	3	23.1
Very Depressed disposition, head and ears down, dull eyes, will not get up	1	7.7
Severely depressed disposition, lateral recumbent	0	0
What fecal score do you consider the threshold for diarrhea? (n=11)		
Normal stool	0	0
Soft to loose stool	6	54.5
Stool is loose to watery	5	45.5
Stool is watery, discoloured, may have blood	0	0
Stool is watery, clear, has blood	0	0
If a calf is recorded with diarrhea is it temporarily removed from the pen it is housed[1] (n=13)		
If house in individual pen, remains in the pen	4	30.8
If housed in individual pen, is moved physically away from other pens	3	23.1
No individual pens on farm	6	46.2
If housed in a group, is moved from the group	2	15.4
If housed in a group, remains with the group	6	46.2
No group pens on farm	5	38.5
If an animal has diarrhea, is the pen cleaned? (n=13)		
Pen or hutch is not cleaned	6	46.2
Bedding is changed in pen or hutch	0	0
Pen is cleaned and new bedding is added	4	30.8
Other	3	23.1
If a calf has diarrhea, what treatment is performed?[1] (n=13)		
Antibiotics	6	46.2
Anti-Inflammatories	6	46.2
Pain Relief	9	69.2
Other	6	46.2

[1]Farmers could select multiple options.

Table 2.4: Recording protocol for respiratory illness, diarrhea, and mortality in computer and written records on thirteen Ontario dairy farms

	Responses	
	n	%
Do you record respiratory illness?[1] (n=13)		
Yes, in computer software	10	76.9
Yes, in paper records	10	76.9
No	0	0
What code is used to record respiratory illness for computer-based recording? (n=10)		
RESP	1	10.0
PNEU	9	90.0
When respiratory illness is recorded in the computer, is any additional information recorded? (n=10)		
Symptoms	0	0
Treatment	10	100
Other	0	0
Are any shorthand notations or codes used to indicate respiratory illness in written records? (n=10)		
Yes	3	30.0
No	7	70.0
When respiratory illness is recorded on paper, is any additional information recorded?[1] (n=10)		
Symptoms	4	40.0
Treatment	9	90.0
Other	1	10
Do you record diarrhea?[1] (n=13)		
Yes, in computer software	8	61.5
Yes, in paper records	10	76.9
No	1	7.7
What code is used to record diarrhea for computer-based recording? (n=8)		
DIAR	4	50.0
SCOURS	3	37.5
Other	1	12.5
When diarrhea is recorded in the computer, is any additional information recorded? (n=8)		
Symptoms	0	0
Treatment	8	61.5
Other	0	0
When diarrhea is recorded on paper, is any additional information recorded?[1] (n=10)		
Symptoms	3	30.0
Treatment	9	90.0
Are any shorthand notations or codes used to indicate diarrhea in written records? (n=10)		
Yes	3	30.0
No	7	70.0
When a calf has died before weaning, is it recorded? (n=13)		
Yes, in computer software	12	92.3
Yes, in written records	6	46.2
No	0	0
If a calf dies within 48 hours of life, how is it recorded in the software? (n=12)		
Death	8	66.7
Still Birth	3	25.0
Other	1	8.3
When a calf has died, is any information included in recording software? (n=12)		
Symptoms	0	0
Cause of death	12	100

Other	0	0
If a calf dies within 48 hours of life, how is it recorded on paper? (n=6)		
Death	6	100
Still Birth	0	0
Other	0	0
When a calf has died, is any information included in written records? (n=6)		
Symptoms	0	0
Cause of death	5	83.3
Other	1	16.7
Who can enter information into recording software?[1] (n=12)		
Farm Owners	9	75
Herd Manager	8	66.7
Employee	3	25
Who enters information into written records?[1] (n=12)		
Farm Owner	8	66.7
Herd Manager	9	75
Farm Employee	4	33.3

[1]Farmers could select multiple options.

2.9 Appendix I

Table 2.5: Neonatal calf management practices on thirteen Ontario dairy farms

	Responses	
	n	%
Are calves treated with Vitamin E/Selenium within the first 7 days of life? (n=13)		
Yes	8	61.5
No	5	38.5
Are calves weighed at birth? (n=13)		
Yes	3	23.1
No	10	76.9
Where do dams primarily calve? (n=13)		
In individual calving pens	2	15.4
In group pens with 2 or more cows	5	38.5
In group pens with 5 or more cows	6	46.2
Other	0	0

Table 2.6: Colostrum management practices on thirteen Ontario dairy farms

	Responses	
	n	**%**
How soon after birth are calves given colostrum? (n=13)		
Within 2 hours of life	7	53.8
Within 5 hours of life	5	38.5
Within 12 hours of life		
Other	1	7.7
How much colostrum is fed per feeding? (n=13)		
2L or less	0	0
4L or less	10	76.9
6L or less	1	7.7
Other	2	15.4
What is the minimum number of colostrum feeding(s) in the first 24 hours of life? (n=13)		
1 feeding	2	15.4
2 feedings	11	84.6
3 feedings	0	0
4 feedings	0	0
What sources of colostrum are fed to calves?[1] (n=13)		
Calves are allowed to suckle the dam after birth	3	23.1
Fresh from dam/pooled	10	76.9
Frozen (thawed) colostrum	8	61.5
Colostrum replacer	7	53.8
Other	2	15.4
Do you test the quality of the colostrum? (n=13)		
Yes	8	61.5
No	5	38.5
What is the primary method for feeding calves colostrum? (n=13)		
Dam	0	0
Bottle	10	76.9
Bucket	0	0
Esophageal tube	3	23.1
Other	0	0
If colostrum is fed from equipment, how is the equipment cleaned?[1] (n=13)		
Hot water	2	15.4
Hot water and soap	10	76.9
Disinfectant other than soap	4	30.8
Other	4	30.8

[1]Farmers could select multiple options.

Table 2.7: Feed management for calves >24 hours of age on thirteen Ontario dairy farms

	Responses	
	n	%
How often are calves fed? (n=13)		
2 times	4	30.8
3 times	2	15.4
4 times	1	7.7
5 or more times	1	7.7
Other	5	38.5
How are calves fed?[1] (n=13)		
Bucket	3	23.1
Bottle	5	38.5
Automatic feeder	7	53.8
Other	2	15.4
If you have an automatic feeder, how often is it cleaned? (n=7)		
Daily	5	71.4
Once a week	1	14.3
Twice a week	0	0
Once a month	0	0
Other	1	14.3
If other feeding equipment is used, how often is it cleaned? (n=13)		
Daily	10	76.9
Once a week	1	7.7
Twice a week	0	0
Once a month	0	0
Other	2	15.4

[1]Farmers could select multiple options.

Table 2.8: Housing management for calves >24 hours of age on thirteen Ontario dairy farms

	Responses	
	n	%
How are calves housed? (n=13)		
Individual pens or hutches	3	23.1
Groups of <5	1	7.7
Groups of >5	2	15.4
Individual and then group pens	7	53.8
How often are individual pens cleaned(n=10)		
Weekly	1	10.0
Every two weeks	0	0
Once a month	2	20.0
Between animals	6	60.0
Other	1	10.0
How often are individual pens rebedded, without deep cleaning? (n=9)		
Weekly	2	22.2
Every two weeks	0	0
Once a month	0	0
Between animals	2	22.2
Other	5	55.5
How often are group pens cleaned? (n=13)		
Weekly	1	7.7
Every two weeks	2	15.4
Once a month	3	23.1
Other	7	53.8
How often are group pens rebedded, without deep clean? (n=13)		
Weekly	6	46.2
Every two weeks	0	0
Once a month	0	0
Other	7	53.8
Does location of calf housing change by season? (n=13)		
Yes	1	7.7
No	12	92.3

[1]Farmers could select multiple options.

3 General Conclusions

3.1 General Discussion

Calf respiratory illness and calf diarrhea remain the two most important dairy calf illnesses because of the effect they have on cost of raising animals, long term health outcomes, and the risk posed to animal welfare (Hultgren and Svensson, 2009; Heinrichs and Heinrichs, 2011). Research has indicated the main risk factors for disease susceptibility, and severity, in calves revolve around housing, nutrition, and on farm management decisions (Medrano-Galarza et al., 2018; Winder et al., 2018). The associations between the risk of calf disease and genetics, however, have not been studied to such an extent. Selection for novel traits like calf disease resistance is a relatively new area of study in comparison to production traits, which have evaluations implemented in many dairy production systems (Miglior et al., 2005). Therefore, the use of genetics to improve calf health is a logical step forward.

Research on the genetics of calf illness has yielded preliminary heritability estimates for calf diarrhea, respiratory illness, and mortality within selectable ranges in the United States (Henderson et al., 2011; Henderson et al., 2011; Gonzalez-Peña et al., 2019). Similar work has yet to be executed with Canadian data but may be possible in the future. To lay the groundwork for such a project, current on farm recording protocols needed to be investigated to ensure useable and accurate phenotypes are being collected. With no explicit governing requirements to record disease incidence in Canadian calves, the true amount of calf illness occurring is hard to estimate. The work presented in Chapter 2 was done to identify what the state of calf health was from producer recorded records in Ontario as well as what records were available on a farm level, with particular focus on respiratory illness and diarrhea. The number of farms recording calf health data as gleaned from a producer-recorded health database was approximately 20% which was lower than the 40% of farms that record cow health events regularly as reported by Koeck et al. in 2012. This discrepancy, however, was not unexpected; the heavy focus on farm management has traditionally focused on cow health and production, including the immediate loss of investment when a cow is sick, as opposed to calf health. However, due to the increase in recognition of the importance of calf health, more farms should be encouraged to record this information in an accessible way. These results may also be indicative of the fact that records that may exist on farm, but never make it to recording software or other accessible formats. Furthermore, a focus group study into calf management by Wilson et. al (2021) indicated some producers found it hard to obtain well trained employees that were equipped to deal with calves and their care. Ensuring employees that are handling calves are educated appropriately may lead to increased recording. Providing clear definitions of calf health disease, similar to work done by Kelton et al. (1998) may be the best way encourage recording, especially if guidelines for how to input records are included. The size of farms in Ontario varies greatly, as do the number of employees on a single farm. Providing easy to follow guidelines that can be adopted by all farms may increase recording, especially for farms that already have software available, but do not use it for calves.

When investigating how farmers recorded diseases there was variation. Most farms surveyed used computer software but not all farms that used software inputted diseases in the same manner. The discrepancy between disease codes used is likely due to the fact that respiratory illness and diarrhea are commonly referred to as pneumonia and scours interchangeably by most industry members. Continuation of the use of these different codes in on-farm recording should not pose a problem to future genetic evaluations if records are combined when used for analysis. For example, calves with a record of respiratory illness and calves with records for pneumonia are placed in the same category of analysis. The creation of a data dictionary could help easily map and connect multiple terms that describe the same disease event onto a single corresponding trait event. Similar combinations of recorded traits were previously done by Gonzalez-Peña et al. (2018) when determining genetic parameters for calf wellness traits, respiratory illness and pneumonia were merged due to farms using one or both terms interchangeably. One issue experienced in this study was the discrepancy between what producers said was being recorded and what was recoverable at an industry level through DHI. Loss of records or discrepancies, such as date of a health event, can occur when records are transferred between formats as reported by Mörk et al. (2010) when looking at health records from Swedish dairy veterinarians. Furthermore, the type of disease and region of farm influenced how complete records were (Mörk et al. 2010). In the same study there was also variation in record quality based on if the veterinarian was state or privately employed (Mörk et al. 2010). In the current study, producers often recorded and treated diseases at similar thresholds, which is a good indication that recorded health events are of similar severity. However, all farms that participated were in geographically similar locations, which means standardized protocol nationwide should still be introduced. Without accurate records available, implementing genetic evaluations for calf health traits in Canada may be difficult.

The study outlined in Chapter 2 was limited in the number of farms that participated in the recording survey. The pre-screening survey given to the producers involved meant the sample of farms used were biased towards recording calf health information. This was done on purpose, as at this stage we wanted to understand what/how calf health is being recorded when farmers do record calf health. Distribution of a shorter survey based on only health recording to a larger number of Canadian herds may provide better national insight, especially if compared to information available to researchers through DHI. Such farms however would still need to be recording calf health information to be eligible.

3.2 General Conclusions

The research described in this thesis sought to 1) provide an overview current calf health recording practices in Ontario, 2) understand the feasibility of a data pipeline from Canadian farms to the genetic evaluation centre at Lactanet and 3) develop the foundation for a standard calf health recording system in Canada. The results indicate calf health records are centrally accessible from only a small proportion of Ontario farms (15%) in comparison to cow health records. Further investigation into Canada-wide calf health records is warranted to build an appropriate information pipeline. Areas of data loss or instances of producers choosing not to record calf health events should be investigated to determine the reason for a lack of recording, and to determine a feasible solution. Using known information from farms that do currently record calf health, standardized recording protocols should be established and eventually be presented to all Canadian producers to use on farm to identify respiratory illness and diarrhea in calves. If calf health records can be consistently and accurately recorded by producers, genetic evaluation for calf health and resiliency is possible.

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