Investigating the use of automated feeder data as potential predictors of morbidity and mortality in pre-weaned dairy calves: A protocol for a scoping review

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Abstract

Background: In early life, dairy calves are at high risk of contracting infectious diseases. Early detection of disease in dairy calves is vital to ensure an intervention is promptly applied to prevent the negative consequences associated with disease. Traditionally, neonatal calves were housed individually in hutches or pens in an attempt to limit disease transfer between calves. However, individual housing has been criticized for limiting calf movement, and preventing calf social interaction. Therefore, group housing of calves has gained popularity throughout Canada and the United States. The introduction of automated calf feeders has allowed farmers to more efficiently raise dairy calves. Automated calf feeders measure a wide variety of parameters each time a calf visits, including the amount consumed, drinking speed, and number of rewarded and unrewarded visits. These parameters are thought to provide insight into calf health and could be used as a predictor for disease in pre-weaned calves. However, there is limited published literature which attempts to characterize this data and its potential relationship with predicting disease.

Objectives: The objective of this scoping review is to characterize the body of literature investigating the use of automated feeder data to predict morbidity and mortality in dairy calves during the preweaning stage. This review will list the parameters that have been examined for associations with disease in calves and identify the gaps in knowledge.

Design: For this scoping review, only primary research will be included. Five databases will be searched for and relevant primary research as well as two databases for conference proceedings. The population will be limited to pre-weaned dairy calves of any breed. The dairy operations must use automated feeders during the pre-weaning period. Any definition of calf illness and disease will be included in the study (e.g. diarrhea, respiratory disease, antibiotic treatments, health scoring). Any parameter measured by an automated calf feeder will be considered for inclusion.

A Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart will be used to describe screening (Liberati et al., 2009). Tables will be constructed to summarize the included studies. These tables will include description of outcome definitions the automated feeder parameters described. The PRISMA-extension for scoping reviews will be used as a framework for reporting this scoping review (Tricco et al., 2018).

Introduction

The period between birth and weaning is one of the riskiest periods for dairy calves to contract disease. A recent Canadian national survey identified a 6.4% mortality rate in pre-weaned female calves, with 66% of these deaths occurring in the first three weeks of life (Winder et al., 2018). Of the mortality and morbidity that occurs in early life, respiratory disease and diarrhea represent the disease of greatest concern (Uetake, 2013). It is estimated that 23% and 22% of calves diagnosed with diarrhea and pneumonia, respectively, are given an antibiotic treatment which can contribute to the development of antimicrobial resistance (Windeyer et al., 2014). Early life antibiotic treatment can lead to reduced growth, and potentially reduce future milk production (Dunn et al., 2018), making the early detection of these diseases vital to calf health and growth.

Traditionally, dairy calves were housed individually in hutches or pens in an attempt to limit disease transfer between calves (Jorgenson et al., 2017). However, this individual housing has been criticized for limiting calf movement, and preventing social interaction among calves (Rushen et al.,2008). Therefore, group housing of calves has gained popularity as it provides calves with proper social interaction and increases the expression of natural behaviours, as well as decreases labour costs (Medrano-Galarza et al., 2017). However, an increased risk of disease has been identified in some studies using group housed calves suggesting there may be some trade-offs for animal welfare (Costa et al., 2016). Group housed calves also provide another challenge to producers: the identification of sick calves. The majority of producers detect sick calves by monitoring behavioural changes, however these changes are subtle and often go unnoticed until there are significant clinical signs of disease present. Studies have shown that producers often underdiagnose diarrhea and pneumonia by 58% and 56% respectively (Sivula et al, 1996). If producers could more efficiently detect early disease in calves and treat, this could lead to reduced calf mortality, and provide improved growth in replacement heifers.

Automated calf feeders are computerized systems that report individual calf feeding behaviours and allow farmers to more easily feed a higher plane of nutrition to calves. In a recent survey of Canadian dairy farms 16% of respondents had made the switch to automated milk feeders, with this number expected to grow in the coming years (Medrano-Galarza et al., 2017). The computerized program allows for producers to track individualized data for each calf including daily milk consumption, the speed of milk consumption, and the number of rewarded and unrewarded visits. Automated feeders are able to provide calves with a larger daily volume of milk, spread throughout the day into several feedings (Medrano-Galarza et al., 2017). This feeding regime more closely mimics nature and allows for more efficient calf rearing.

Currently, researchers have identified a handful of behavioural parameters measured by automatic feeders exhibited by calves when they are becoming sick. These parameters include decreased daily milk volume, slower drinking speed, and a decreased number of unrewarded visits (Knauer et al., 2017; Svensson and Jensen, 2007; Sutherland et al., 2018). While the identification of these behaviours has been vital, additional

information is needed to allow producers to efficiently utilize this data. Specifically, research is needed into these behaviours to determine thresholds for the identification of disease, and to evaluate their ability to predict disease.

Objectives

The objective of this scoping review is to characterize the body of literature investigating the use of automated feeder to predict of morbidity and mortality in preweaned dairy calves. The review will list the parameters that have been examined for associations with disease and death in calves and discover gaps in knowledge.

Methods

Protocol and Registration

This protocol will be archived and available online in the Atrium at the University of Guelph (https://atrium.lib.uoguelph.ca/xmlui/handle/10214/2045).

Eligibility Criteria

Primary research will be eligible for inclusion and all types of analytical studies will be included. The population will be limited to dairy calves of any breed or sex, from birth to weaning as long as they are fed using an automatic calf feeder for all or a portion of the pre-weaning period. Only publications in the English language will be included for the scoping review. There will be no geographical or date restrictions placed on the eligibility.

Information Sources

The literature search will be conducted online through the McLaughlin Library, University of Guelph in the following databases: Medline (via Ovid) Scholars Portal Journal (via OCUL), CAB Direct (via CABI), ProQuest (Agricultural & Environmental Science Database, Biological Science Database, Dissertations & Theses @ University of Guelph), Web of Science (via Clarivate) and Scopus (Via ?). For conference proceedings, the American Association of Bovine Practioners (1997) and World Buiatrics Congress proceedings (2008) will be searched.
Add ACRICOLA (via proquest)

Search

Upon formation of the list of search terms, a preliminary search will be performed looking at titles and abstracts of relevant papers to determine if all search terms are appropriate and included. A forward search of relevant papers will be performed to obtain additional sources to be used for a cross-check once the search is done. Results of the test search in CAB Direct (via CABI) are listed in Table 1. A final validation of the search was done by identifying 22 relevant studies determined by JC, which are listed as an appendix.

Table 1. Results of an initial to identify studies reporting or examining automatic milk feeder data with relation to morbidity and mortality in dairy calves in CAB Direct (via CABI).

#	**Search Terms**	**Results**
1	(bovine or dairy or veal or Holstein or Jersey or "brown swiss" or gurnsey or aryshire or "milking shorthorn" or heifer or bull)	612,801
2	(calf or calves)	138,425
3	("milk feed*" or "calf rail" or "calf feed*" or "AMF" or "robotic feed*" or "computer feed*" or "computer controlled feed*" or "computer-controlled feed*" or "automatic feed*" or "automated feed*" or "milk feeding system" or "calf feeding system" or "robotic feeding system" or "computer feeding system" or "computer-controlled feeding system" or "computer controlled feeding system" or "automatic feeding system" or "automated feeding system or milk fed*")	13,038
4	1 AND 2	72,945
5	1 AND 2 AND 3	2,734

Data Management

Results from all database searches will be uploaded to EndNote (Clairvate Analytics, Philadelphia, USA) reference management software, and duplicate studies will be documented and removed. Once complete, references will be uploaded to DistillerSR (Evidence Partners Inc., Ottawa, Canada) checked again for duplicates, after which studies will be screened and data extraction completed.

Selection of Evidence

There will be two levels of screening for this scoping review. Each level of screening will be completed independently by two reviewers.

Articles obtained using the search terms will undergo screening based on the title, abstract, and key terms. The articles will be reviewed using the list of questions below that will be answered with "yes", "no", or "unclear". If there is disagreement between reviewers, article will be labelled "unclear". Any articles which are labelled "yes" or "unclear" to all questions will proceed, those with a "no" response to any question will be excluded. Agreement will be at the form level. The first 150 articles will be a pre-tested to ensure both reviewers apply questions consistently.

1. Is the title/abstract available in English?
2. Is the citation primary research?
3. Does the title/ abstract/ index terms describe a study investigating the use of automated feeder data as a predictor of morbidity or mortality in pre-weaned dairy calves?

Articles passing title/abstract screening will have the full text publications obtained. The following questions will be answered using either "yes" or "no". A "no" to any questions will result in exclusion, and articles with a "yes" to all five questions will be included. Agreements will be at the question level, and disagreements will be resolved using

consensus, with the intervention of a third reviewer if necessary. There will be a pre-testing period of 10 articles to ensure both reviewers have a similar understanding to the questions.

1. Does the full text article/conference proceeding describe a primary research study?
2. Is the full text article/conference proceeding available in English and contain >500 words?
3. Does the full text article/conference proceeding include the usage of automated milk feeders during the pre-weaning stage for dairy calves?
4. Does the full text article/conference proceeding investigate morbidity or mortality in dairy calves?
5. Does the full text article/conference proceeding investigate the use of automated milk feeder parameters as a predictor of morbidity or mortality in dairy calves?

Data Extraction

Two reviewers will independently perform data extraction, resolving any conflicts using consensus. If consensus cannot be reached, a third reviewer will mediate. Reviewers will pre-test the data extraction form for the first 10 articles to ensure both reviewers fully understand the form and how to complete it. Data extraction will include:

1. General characteristics of the study: publication year (or conference year), year and time of year study was conducted, and country where study was completed
2. Study approach
    a. Descriptive (case report, descriptive studies, etc.)
    b. Analytical (hypothesis testing)
3. Objective and hypotheses of study
4. Population of study: farm type, herd size, breed, sex, age, housing type, automatic feeder type (rail of feeder) and brand
5. Sample size
6. Automated feeder parameters examined:
    a. amount drank (L/ day, L/ visit)
    b. drinking speed (L/min)
    c. rewarded or unrewarded visits (per day)
    d. Other
7. Morbidity and mortality definition:
    a. Time at risk of each outcome
    b. Morbidity definition
        i. Health scoring (if applicable)
        ii. Disease definitions (if applicable)
        iii. Treatment as a proxy for disease
            1. Antibiotic treatments
                a. Type of antibiotic/ antimicrobial
                b. Definition of a single treatment
            2. Therapies given other than antibiotics (i.e. electrolytes, other)
        iv. Outcome assessor (Veterinarian, trained staff, researcher, other)?

Data Reporting

Charting Process
The study and conference proceeding process will be described using the PRISMA flowchart (Liberati et al., 2009). Frequency tables will be constructed to summarize the included studies. These tables will include a list of the types of diseases observed, the automated feeder parameters described, and the length of time these parameters were observed in included studies. The PRISMA-extension for scoping reviews will be used as a framework for this scoping review (Tricco et al., 2018).

Synthesis of Results
Study statistics including descriptive analysis of study characteristics (date and country of publication), sample size, and study approach will be recorded using tables. Definitions of each disease and automated feeder parameter will also be included from each study as well as general conclusions drawn by authors. Necessary figures will be included to further demonstrate the descriptive data discovered in the eligible studies.

Selection of Sources of Evidence
A flowchart as described by Liberati et al. will be used to portray the study inclusion process (2009). This will include the number of included studies at each level of the selection process, as well as how many studies are excluded at each step in the process. The full web search strategy for at least one database will be included in a summary table.

Characteristics of Sources of Evidence
Study statistics including descriptive analysis of study characteristics (date and country of publication), sample size, and study approach will be recorded using tables.

Results of individual Sources of Evidence
With this scoping review, the aim is to identify eligible research papers which have investigated the use of automated feeder data as a predictor of morbidity and mortality in dairy calves during the preweaning stage. We will report the definition of disease and parameters of automated milk feeders investigated, as well as the study methodology used in each study.

Limitations
Limitations at the study and review level will be discussed.

DISCUSSION

This scoping review will provide a summary of primary research and conference proceedings investigating the use of automated feeder data as a predictor of morbidity and mortality in dairy calves during the preweaning stage. Our results will be used to identify gaps in knowledge and guide future research into this topic. Keeping pre-weaned dairy calves healthy is vital to animal welfare and the future of the dairy herd.

Characterizing the parameters of automated milk feeders which pertain to disease prediction in these calves, will provide key knowledge to producers throughout Canada.

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Appendix

Appendix 1. List of 22 references identified by JC used for validation of initial database searches

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