Background: Proper calf care is essential to reduce morbidity and mortality rates. Identification of potential risk factors associated with the development of disease is the first step towards improving calf management. Umbilical infections are common in calves and requires further research to produce more conclusive recommendations to improve animal welfare and productivity.

Objective: The objective of this scoping review is to describe and characterize the existing literature regarding umbilical health and highlight current gaps in knowledge. This will include descriptive studies, studies examining risk factors associated with umbilical health, and studies examining the consequences of poor umbilical health.

Design: Evidence will be drawn from primary research studies including descriptive and analytical studies. The population will be exclusively bovines on dairy, veal, feedlot, cow-calf or dairy beef operations. Five databases will be searched for relevant primary research. Literature that fits within the search terms will be uploaded onto Endnote where title and abstract screening will be conducted by two independent reviewers. Evidence that meets the title/abstract inclusion criteria will be screened again using the full text. Following full text screening the reviewers will resolve all conflicts and start data extraction from the approved texts. Relevant records will then be described and characterized using tables and figures.

Introduction

Neonatal calf management is of vital importance to producers due to the susceptibility of newborn calves developing disease. It was identified in Canada that pre-weaned female calves have a mortality rate of approximately 4.2% in the first 4 weeks of life (Winder et al., 2018). By reducing the mortality and morbidity rates of calves, it can not only increase animal welfare but also increase the productivity and profitability of Canadian producers.

There is a large body of new research examining the long-term benefits of calf care in early life. This includes improved housing facilities, biosecurity protocols and ensuring timely clean colostrum consumption. However, there remains a knowledge gap regarding risk factors associated with poor umbilical health and understanding the impact that poor umbilical health has on calves.
The umbilical cord is the connection between the cow and her fetus that allows the passing of nutrients, oxygen and waste (Robinson et al., 2015). The cord is primarily made up of two arteries, a vein, and the urachus (Fubini & Ducharme, 2017). Following parturition, the umbilical cord dries and detaches leaving a bump which is known as the navel (Fubini & Ducharme, 2017). It is during this drying period when the umbilical cord is open to the surrounding environment, allowing pathogens to enter the umbilicus and cause disease (Robinson et al., 2015). Once a pathogen enters the umbilical cord, it can cause an infection which triggers an immune response (Fubini & Ducharme, 2017). Infection of any or all the umbilical structures is known as omphalitis (Steerforth & Robinson, 2018). A sequelae to omphalitis could bacteraemia leading to an infection that localizes in the joints of the calf resulting in pain and further health complications (Steerforth & Robinson, 2018).

There is a wide discrepancy in the reported incidence of umbilical infections in calves. Some older literature has suggested a range of 1-14% of dairy calves will develop umbilical infections (Virtala et al., 1996), however new research coming out of Cornell University has found an incidence rate of 27% in new born-calves (Weiland et al. 2017). The local infection then has the possibility to spread to the rest of the calf and

Research conducted at the University of Guelph, found an association between abnormal navel scores and a higher hazard of early mortality (Renaud et al., 2018). Additionally, the United States Department of Agriculture published a producer report stating that 3% of all pre-weaned heifer deaths occurred due to navel and joint problems (USDA, 2018).

Describing and characterizing research surrounding umbilical health, including describing research examining risk factors associated with the development of poor umbilical health and the consequences of poor umbilical health, can provide shareholders with improved knowledge to make informed changes to their management styles and produce healthier and more profitable calves.

**Objective**

The objective of this scoping review is to describe and characterize the existing literature regarding umbilical health and highlight current gaps in knowledge. This will include descriptive studies, studies examining risk factors associated with umbilical health, and studies examining the consequences of poor umbilical health.

**Methods**

**Eligibility**

Sources will be drawn from primary research studies including observational and experimental studies, excluding case reports and case series. The target population will be limited to bovines
that are on dairy, veal, feedlot, cow-calf and dairy beef operations. However, all small holder and/or dual purpose animal operations will be excluded from the study. This includes articles on bovines of any sex or age with no geographical or date of publication limitations. The publications must examine an aspect of umbilical health including: prevalence or incidence of umbilical infection or abnormalities, risk factors for umbilical health, or umbilical health as a risk factor. Furthermore, only articles published in English will be included in the scoping review.

Information Sources

The following data bases will be accessed online through the University of Guelph McLaughlin library: CAB Direct (via CAB Interface), SCOPUS, ProQuest dissertation and thesis, Argicola (via ProQuest), Medline (via Ovid), and Science Citation Index Expanded (SCI-EXPANDED), Conference Proceedings Citation Index-Science (CPCI-S), and Emerging Sources Citation Index (ESCI) (via Web of Science).

Search

Search terms designed prior to the first round of literature screening will be used to conduct a preliminary search of each data base to ensure that the terms are appropriate and yield a functional number of results. The total number of results from the preliminary test search of web of science can be found in table 1. All results from database searches will be transferred to the reference data management software Endnote. Following reference uploading duplicate studies from all databases will be documented and removed before screening.

Table 1. Initial search results obtained from SCI-EXPANDED, CPCI-S, and ECSI (via Web of Science) conducted on November 26th 2019.

<table>
<thead>
<tr>
<th>Number #</th>
<th>Search Term</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Bovines or Veal or Dairy or Calf or Calves or Heifer or Cow or Bull or Sire* or Steer* or Beef or Cow-calf or Dairy-beef or Feedlot)</td>
<td>759,305</td>
</tr>
<tr>
<td>2</td>
<td>(Navel or Umbilical or umbilicus or omphalos)</td>
<td>88,675</td>
</tr>
<tr>
<td>3</td>
<td>1 AND 2</td>
<td>1860</td>
</tr>
</tbody>
</table>

Title & Abstract Screening

Two reviewers will independently read the title and abstract of the literature identified using the search terms to determine if they are appropriate to include in the scoping review. Each reviewer will examine each article independently and evaluate using the listed questions 1-3 below (see preliminary study selection). Each reviewer will then answer and record questions 1-3 with a “yes”, “no” or “unclear”. Articles that receive a “yes” or “unclear” to all 3 questions by
both reviewers will be included in the next phase of full text screening. Articles that have an agreed upon “no” to any question will be excluded. If reviewers disagree they will resolve the conflict via consensus; all unresolved disagreements will be resolved by a third party. Following review of the first 100 articles the two parties, will meet and go over their results to ensure they are accurately and consistently applying the study selection criteria.

Preliminary Study selection

1. Is the title/abstract in English?
2. Does the title/abstract describe a primary research article?
3. Does the title/abstract include any aspects of umbilical and/or navel health in bovines?

Full Text Screening

Following the title and abstract screening, included studies will undergo full text screening. Each reviewer will independently read the full text and answer questions 1-5 below with either a “yes” or “no”. Articles that are given a “yes” to all questions by both reviewers will be included in the scoping review. Articles that receive an agreed upon “no” to any or all the questions will be excluded from the scoping review. All full text exclusions and reasons for exclusion will be reported. Disagreement by the two reviewers to any question(s) will be resolved via consensus and any unresolved conflicts will be determined by a third party. Following review of the first 10 full text articles, the two parties will meet and go over their results to ensure they are accurately and consistently applying the study selection criteria.

Full text study selection

1. Is the full text available?
2. Is the full text in English?
3. Is the full text > 500 words?
4. Is the full text a primary research article describing an observational or experimental study? (Includes controlled trials & observational studies – cohort/case control/cross sectional)
5. Does the full text describe an examination of prevalence or incidence of umbilical health or abnormalities, examination of risk factors of umbilical health (including intervention studies), or examination of umbilical health as a risk factor?

Data Extraction

Following full text screening, both reviewers will perform data extraction using the list included below. Any conflicts that may arise will be resolved via consensus and any unresolved conflicts will be resolved by a third party similar to the abstract and full text screening process. Following the review of the first 10 full text pieces of literature, the two parties will meet and go over their results to ensure they are correctly completing the data extraction.
1. Study characteristics: author(s), year of publication/presentation and country (if applicable province/state) where study was conducted.

2. Type of study:
   A) Observational
      i. Cross sectional
      ii. Cohort
      iii. Case control
   B) Experimental
      i. Clinical trial,
      ii. Challenge trial

3. Population of interest:
   A) Target population
      i. Breed
      ii. Sex
      iii. Age
      iv. Unknown
   B) Sample population
      i. Breed
      ii. Sex
      iii. Age
      iv. Unknown

6. Type of operation. (Dairy, Beef, Cow-calf, Dairy-beef, Feedlot, Veal)

7. Research or commercial herd(s)

8. Sample Size (number of herds/pens/animals)

9. FOR DESCRIPTIVE STUDIES
   A) Prevalence/incidence
   B) Outcome(s)
      1. Case definition
      2. Time at risk (if applicable)

10. FOR ANALYTIC STUDIES
    A) Clinical trials
        1. Description of the intervention(s)
        2. Description of all outcomes pertaining to umbilical health
           1. Case definition
           2. Time at risk
    B) Observational studies - risk factors for umbilical health
       i. List exposures measured
       ii. Description of all outcomes pertaining to umbilical health
C) Observational studies - umbilical health as a risk factor  
  i. Describe how the exposure of umbilical health was assessed  
     a. Case definition  
  ii. List all outcomes measured  
     a. Case definition  
     b. Time at risk

Discussion

The scoping review will seek to characterise the current literature that has examined umbilical health in bovines: those describing prevalence or incidence of umbilical abnormalities, those examining risk factors associated with umbilical health, and those examining consequences of poor umbilical health. The results from the scoping review will be used to summarize current knowledge and to discover areas that need improvement and future research. It will support future work to identify risk factors associated with umbilical morbidity is a fundamental to preventing poor umbilical health and improve calf welfare. The characterization of literature on this topic will aid Canadian producers in producing healthy and profitable calves.


