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Dairy cow mortality data management: the dairy certificate of death

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Abstract

On-farm cow mortality is a significant problem for North American dairies. Analysis of causes of death should provide important information about outcomes of current management, and direction for management changes required to improve cow health, production, and well-being. Currently available information about mortality losses is not useful for making appropriate changes because information gathering and storage are inadequate for that purpose. Here we propose and analyze the use of a dairy cow death certificate that provides an information gathering tool intended to improve analysis and communication about outcomes of dairy management.

Key words: dairy, mortality, cause of death

Résumé

La mortalité des vaches à la ferme est un grave problème des fermes laitières en Amérique du Nord. L'analyse des causes de cette mortalité devrait fournir des renseignements importants sur les conséquences de la régie actuelle et sur la direction que pourrait prendre les changements de régie afin d'améliorer la santé des vaches, leur production et leur bien-être. L'information présentement disponible sur les pertes associées à la mortalité n'est pas utile pour faire des changements appropriés parce que la collecte et l'entreposage de l'information ne sont pas adéquats à cette fin. Nous proposons ici et analysons l'utilisation d'un certificat de décès pour la vache pouvant servir d'outil de collecte d'information afin d'améliorer l'analyse et la communication des résultats de la régie des fermes laitières.

Introduction

Dairy cow mortality levels in North America have risen over the past several decades, suggesting that some aspects of modern dairy systems increase the risk of death.[3,17,19] This is both a financial concern and an important animal welfare issue. Summary studies of dairy cow removal have been in the literature for decades, but information specifically related to mortality has been sparse.[15,22] Understanding the timing and fates of animals that die on farms can be informative in their reflection of management conditions and disease outcomes. These provide a foundation for improved understanding of cow health and features of farm management that present risks of poor outcomes. An accurate description of dairy cow mortality is needed to reduce the economic and animal welfare costs, as well as the reputational risk posed to the industry.[3]

The historical lack of robust information about causes of cow death in the literature and on individual farms demonstrates that this aspect of cow removal has not been closely monitored or managed. There is no evidence that any 1 thing has led to the rise in mortality. Rather, numerous factors apparently act in concert to influence specific outcomes that may lead to death. That there is a wide range of death losses across dairies suggests that different farm features and varying dairy management are very influential.

Decreasing cow death losses logically requires that management needs to be directed at minimizing those factors that increase risk of death. But this requires information gathering and analysis that identify those risk factors on an individual dairy. Such systems appear to be lacking on most North American operations. Here we propose a specific system to collect information and identify mortality risks.

Associations with Mortality

Several recent epidemiologic studies have identified some of the dairy features related to increasing mortality. These have analyzed associations between mortality levels and population characteristics such as parity, disease prevalence, days in lactation, or pregnancy.[11,15,19,22] Increases in herd size, average somatic cell count, or the proportion of purchased cows have also been shown to result in an increasing mortality risk at the herd level.[6,17,20,23] Further, genetics have been implicated as an underlying component of increasing death losses due to selection biased toward production indices, with little consideration of animal longevity or disease occurrence.[5,15] While such studies are very helpful

in understanding the nature of the problem, the results generally cannot be used to make consequential management decisions on farms. For example, it is unlikely an operator will decide not to expand the herd to avoid potential death loss problems, and most herd owners already strive to manage disease issues. A different level of on-farm information is needed to identify unique farm characteristics underlying mortality risks.

Pathophysiologic and Anatomic Descriptors of Death

The limited published information available to describe specific causes of cow mortality has mostly been derived from on-farm records. Unfortunately, these descriptors of the causes of death are almost exclusively based upon owner or farm worker impressions with very limited veterinary input. The most recent national dairy survey from the National Animal Health Monitoring System reported that <5% of cow deaths are evaluated by necropsy.[25] Thorough necropsy-based postmortem evaluations are an underutilized but important means for defining the pathologic explanation of dairy cow deaths. Several studies have defined dairy cow death losses based on pathophysiologic or anatomic descriptions.[13,26,28] These studies show a wide array of different causes of disease and death. The value of a postmortem evaluation is directly related to the accuracy and maintenance of data collected and its application to operational management. Individual deaths can be defined by specific pathological findings, but this level of detail is difficult to analyze for underlying herd-level problems, and is itself limited in its account of the sequence of events that lead to the death.[12]

Categorizing Dairy Cow Death

Capturing information regarding why cows die presents a substantial challenge. Thomsen and Houe's review of dairy cow mortality found that only 10 of 19 studies gave some information on causes of death, and none of the diagnoses were validated by necropsy examination.[22] Consequently, the causes of death within much of the relevant literature are based solely on antemortem histories. Categories used to describe deaths have been relatively uniform across studies and have included accidents, calving disorders, digestive disorders, locomotor disorders, metabolic disorders, udder/teat disorders, other known reasons, as well as unknown reasons. The level of detail is variable, and most studies have a relatively large proportion of causes classified as 'unknown' (16 to 46%).[22,24] Although these categorical groupings are commonly used, there is no information in the literature to validate that these groupings are useful for directing management changes or that they are even used for such a purpose.

Cause of Death in Human Public Health

For years our understanding of human causes of death has been based on the concept of underlying, intermediate, and immediate Causes of Death (COD).[16] This concept suggests there are a set of circumstances or events that underlie the development of specific pathology, and this pathology ultimately results in the death. Therefore, a postmortem examination can reveal the pathology, but needs to be matched with other information about the individual to understand why that pathology occurred. Such information might include descriptors of age, preceding health events, weather, location near time of death, diet, and so on. This holds true for veterinary as well as human medicine.

Within literature relevant to human health, the underlying cause of death has been "defined pragmatically as the entity initiating the causal chain leading to death."[10] This reasoning is familiar to anyone who has read mystery novels or watched some of the recent crime shows on television. Although not every mystery involves a dead body, every dead body is a mystery.[18] The fact that an individual has died from a specific cause, for example a gunshot or perhaps an automobile accident, is only meaningful in the context of other information that describes why the individual was shot, or how the accident occurred. To prevent future deaths requires that the underlying cause of death is identified and mitigated to reduce risks for other individuals in the future. Very importantly, much of this additional information must be gathered at, or near, the time of death because many of the details are lost or cannot be identified at a later time.

This rationale has served well in human medicine for many years, and it is incorporated into death certificates. These formal documents combine information about the specific assessment of the proximate cause of death, commonly including autopsy information or results of ancillary testing, plus other historical assessments and characteristics of the individual that lead the health official to define underlying, intermediate and immediate COD within a cause of death statement (CODs). Death certificates can be challenging to accurately fill out, and are only completed for approximately half of the people who die annually worldwide. Despite this limitation, they represent the remarkable idea that death should be accounted for, and by documenting causes of death we can solve its mystery.[18,27] They serve to document trends and outcomes of health policy, and play a role in directing health management interventions.

Nothing like this exists in the information systems currently used on dairies, despite the fact that many veterinarians do informally conduct such an analysis under those few circumstances when a necropsy is performed. Further, even when a veterinarian has performed such analysis, the results are rarely codified or stored for comparison with future findings. Instituting a process like the one used in human health systems, and codifying results for further analysis and interpretation to guide management decisions, could be a major step forward in decreasing risk of death on dairies.

Dairy Certificate of Death Study

The lack of uniform dairy CODs limits the ability of dairy producers to monitor mortality in relation to variables such as diseases and other health problems, and characteristics and circumstances of the animals affected. Current on-farm record systems are focused on details related to an animal's life history features (e.g., birth date, lactation number, lactational and reproductive status). These are the sort of details that the US Standard Certificate of Death records prior to the CODs. It is the actual CODs that have no realistic equivalent within dairy record systems.

Incorporating death certificates with CODs into dairy systems is achievable. Clearly CODs are different for cows than for humans, but the underlying principles are the same. Individual life history features are available and can be transferred easily from on-farm databases into formatted death certificates. As with human CODs, a dairy death certificate should record the estimated chain of events leading up to a death. Although the details defining the various causes of death (underlying, intermediate, and immediate) may rely on incomplete data, focus on this challenge can provide the impetus to enhance dairy- and cow-related data acquisition, including postmortem evaluations. Importantly, shifting the focus away from the immediate cause of death to the process underlying a death affords an opportunity to improve communication between the various employees providing health care on a dairy, veterinarians, nutritionists, and owners.

A prototype Dairy Certificate of Death is presented in Figure 1. It was used to catalogue dairy cow deaths on the participating dairy in this retrospective study of adult cow (lactation > 0) mortality records from January 01, 2014 through June 30, 2016. Colorado State University (CSU) dairy veterinarians implemented the death certificate in 2013 as an ongoing aid in assessing mortality on this intensively managed, high-producing (approximately 27,500 lb (12,500 kg) milk/cow/year) commercial dairy in northern Colorado. Routine herd health oversight by CSU veterinarians included the completion of necropsies and a death certificate for the majority of dead cattle. The death certificate included a CODs and additional room for documenting necropsy findings and other important contributors to death accessed through previous records and farm personnel insight. Hard copies of the death certificates were kept on file both at the dairy and at CSU.

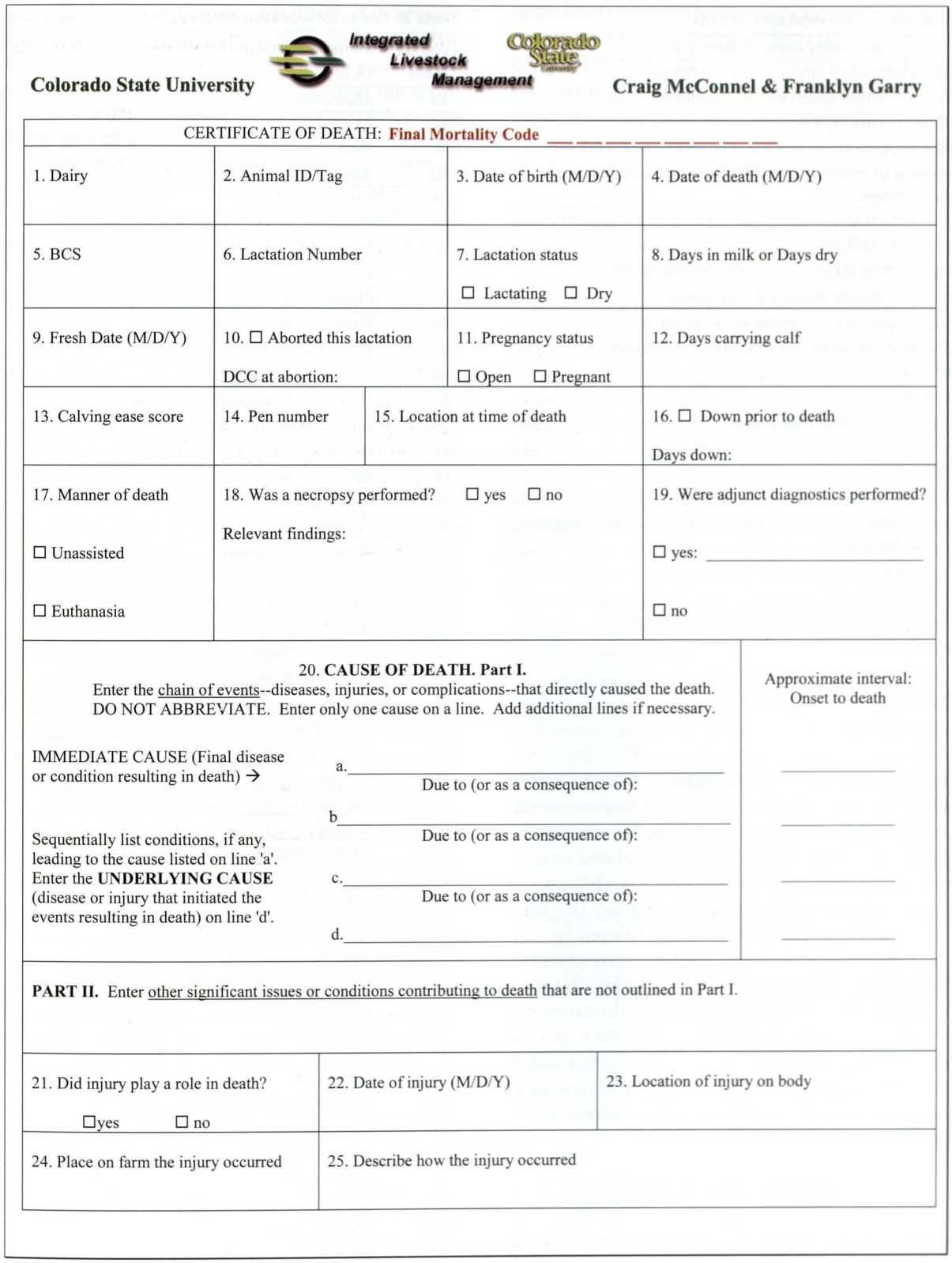
The dairy was closed to externally sourced cattle, and maintained a stable inventory of approximately 1,450 adult (lactating and dry) Holstein cows. Cows were predominantly housed in freestall barns using sand bedding. The average dry period was 51 days, with dry cows separated into far-off, close-up, and maternity pens. Cows were moved to the close-up pen 3 weeks prior to their freshening date and to the multiple animal maternity pen approximately 1 week prior to freshening. Heifers and mature cows were grouped together within the close-up, maternity, and fresh pens. Fresh cows were penned separately from hospital cows, and after approximately 21 DIM lactating heifers were grouped separately from mature cows. Operational management included the use of on-farm computer systems to track cow and herd-level data, including mortality records.

Mortality Codes

Information recorded within the death certificate was distilled into a code (Table 1) for ease of data management within on-farm computer software[a] and analyzed through the use of Pivot Tables and chi-squared or Fisher's exact tests.[b] Rather than using a constrained remark of 8 or so characters to simply record the immediate cause of death in abbreviated, generic terminology (i.e. diarrhea, mast, trauma, etc.), it was possible to capture a more complete record of causality within those same 8 characters using codes for pre-defined categories and events. Each death was initially categorized according to broad, descriptive themes based on previous research (Table 2).[12] Additional information related to euthanasia or death by natural causes, the completion of a hard-copy death certificate, and proximate and underlying causative factors also were included in the code. Table 3 provides a list of codes used to identify immediate, intermediate, and underlying diseases or causative factors. Using the combination of codes for themes/categories and specific, influential diseases or injuries created a relatively thorough data stream for easy storage, retrieval, and future analysis.

Deaths assessed by CSU veterinarians on the participating dairy were documented using the death certificate, with or without a necropsy, with a requisite mortality code applied per case. Veterinarians who were involved in documenting mortalities were guided through their initial use of the Dairy Certificate of Death by 1 of the authors (CM). A list of mortality themes and codes used to identify underlying, intermediate, and immediate factors were kept in the dairy ambulatory truck in a "Dairy Certificate" notebook with blank certificates. Additional codes were added as needed by the participating veterinarians. A single demonstration was deemed adequate by all participants for understanding the process of filling in the certificate of death including necropsy findings, the CODs, and other significant issues or conditions contributing to the death.

For those cases where veterinary input for a death was unavailable, the herd owner and manager provided their assessment and categorization of a given death using the same mortality codes, but without the benefit of a death certificate or necropsy. As an example of a mortality code, an animal that died due to hemorrhagic bowel syndrome was coded DZDYHBxx (DZ = specific disease process to target for intervention; D = died of natural causes; Y = death certificate completed by veterinarian; HB = hemorrhagic bowel syndrome as the immediate cause of death; xx = no relevant underlying or intermediate disease process). An animal euthanized due to severe calving trauma was coded ICEYVTDY (IC = injury



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CERTIFICATE OF DEATH: **Final Mortality Code** _ _ _ _ _ _ _ _ _

1. Dairy	2. Animal ID/Tag	3. Date of birth (M/D/Y)	4. Date of death (M/D/Y)
5. BCS	6. Lactation Number	7. Lactation status ☐ Lactating ☐ Dry	8. Days in milk or Days dry
9. Fresh Date (M/D/Y)	10. ☐ Aborted this lactation DCC at abortion:	11. Pregnancy status ☐ Open ☐ Pregnant	12. Days carrying calf
13. Calving ease score	14. Pen number	15. Location at time of death	16. ☐ Down prior to death Days down:
17. Manner of death ☐ Unassisted ☐ Euthanasia	18. Was a necropsy performed? ☐ yes ☐ no Relevant findings:		19. Were adjunct diagnostics performed? ☐ yes: _____ ☐ no

20. **CAUSE OF DEATH. Part I.**
Enter the chain of events--diseases, injuries, or complications--that directly caused the death. DO NOT ABBREVIATE. Enter only one cause on a line. Add additional lines if necessary.

Approximate interval: Onset to death

IMMEDIATE CAUSE (Final disease or condition resulting in death) →
a. _____ Due to (or as a consequence of): _____
b _____ Due to (or as a consequence of): _____
Sequentially list conditions, if any, leading to the cause listed on line 'a'. Enter the **UNDERLYING CAUSE** (disease or injury that initiated the events resulting in death) on line 'd'.
c. _____ Due to (or as a consequence of): _____
d. _____

PART II. Enter other significant issues or conditions contributing to death that are not outlined in Part I.

21. Did injury play a role in death? ☐yes ☐ no	22. Date of injury (M/D/Y)	23. Location of injury on body
24. Place on farm the injury occurred	25. Describe how the injury occurred	

Figure 1. Dairy Certificate of Death with Cause of Death Statement. Source: McConnel CS. Dairy cow mortality, PhD Dissertation, Fort Collins, Department of Clinical Sciences, Colorado State University, 2010; 179.

Table 1. Coding scheme for mortality records.

Mortality code: letters 1-8	
1-2)	Category related to target area for intervention
3)	Euthanized versus death by natural causes (E/D)
4)	Death certificate (Y/N)
5-6)	Immediate/proximate disease related to cause-of-death
7-8)	Underlying or intermediate disease process or causative factor if known

Table 2. Categorization scheme for dairy cow mortality.

Death themes & categories
• Specific disease process as a stand-alone problem
DZ: Specific disease such as hemorrhagic bowel syndrome, metritis, etc.
• Traumatic injury
IC: Injury related to calving trauma
IJ: Injury such as spinal, stifle or hip damage
HE: Trauma due to human error
• Multifactorial failures linked to transition period
TN: Multifactorial transition/early lactation disease or negative energy balance issues
• Feed management
FD: Feeding error
• Miscellaneous events not conducive to prevention
MS: Miscellaneous
• Undetermined
UN: Undetermined

related to calving trauma; E = euthanized; Y = death certificate completed by veterinarian; VT = vaginal trauma as the immediate cause of death; DY = dystocia as the underlying cause of death). An early postpartum death related to multiple diseases was coded TNDYSEDA (TN = multifactorial transition cow/early lactation disease problems; D = died of natural causes; Y = death certificate completed by veterinarian; SE = septicemia as the immediate cause of death; DA = displaced abomasum representing an intermediate disease process). Finally, on-farm euthanasia by the farmer of a chronically lame cow was coded DZENLMSA (DZ = specific disease process to target for intervention; E = euthanized; N = no death certificate completed; LM = generic lameness as the immediate cause of euthanasia; SA = sole abscess as the disease process underlying the lameness).

Assessment of Mortality Records

A total of 223 adult cow deaths were recorded from January 01, 2014 through June 30, 2016, with 91 in 2014, 82 in 2015, and 50 during the first six months of 2016. This equated to an annual mortality percentage (number of annual deaths divided by the average 1,450 lactating and dry cows) of 6.3% during 2014, 5.7% during 2015, and 6.9% through the first half of 2016, with no difference between years (chi-

Table 3. Codes for disease process related to cause of death.

Disease codes	Immediate/Intermediate/Underlying Disease or Causative Factors
AB	Abomasitis
BK	Back injury
BL	Bloat
BO	Bleed out/hemorrhage
CA	Cancer
CH	Choke
CC	Concrete flooring
CE	Cancer eye
CL	Clostridial leg
CN	Congenital defect
CT	Cecal torsion
DA	Left displaced abomasum
DI	Diarrhea/infectious gastrointestinal disease
DW	Down cow
DY	Dystocia
ED	Edema
FL	Fatty liver
FR	Footrot
FS	Freestall/facility issues
FW	Footwart
HB	Hemorrhagic bowel syndrome
HP	Hip displacement
HW	Hardware disease (TRP)
HT	Heart pathology
IC	Ice
IN	Indigestion
JN	Johne's disease
KE	Ketosis
LG	Leg injury
LI	Listeria
LM	Generic lameness--needs attributed to specific causative factor
LV	Liver abscesses
MA	Mastitis
MC	Malignant catarrhal fever
ME	Metritis
MF	Milk fever/metabolic
MV	Mesenteric root volvulus
PA	Parlor issues
PE	Peritonitis
PN	Pneumonia
RD	Right displaced abomasum
RN	Renal disease/failure
RP	Retained placenta
SA	Sole abscess
SE	Septicemia
SH	Shoulder injury
SJ	Septic joint
ST	Stifle injury
UI	Udder injury
UL	Perforated gastrointestinal ulcer
UT	Uterine tear
VT	Vaginal trauma

squared $P = 0.5$). There were 141 mortalities with a death certificate, of which 134 (95%) were necropsied. None of the 82 mortalities without a death certificate were necropsied. Table 4 demonstrates the itemization of deaths for those with and without a death certificate. Mortality codes were exported from DC305 and analyzed using Pivot Tables, with each death attributed to 1 of 8 general categories. Within each category the deaths were further assessed relative to any attributed immediate and underlying COD. Death certificates were utilized to investigate additional important contributors to a given mortality.

The majority of deaths were assigned to the general category representing specific diseases as a stand alone problem (DZ), which was similar for those with (80/141; 57%) and without (49/82; 60%) death certificates. For those without death certificates, traumatic injuries (IC, IJ, or HE) were the predominant alternative categories (24/82; 29%). The distribution across categories was more uniform for those with death certificates. Traumatic injuries (19/141; 13%), miscellaneous events not conducive to prevention (MS; 15/141; 11%), and multifactorial failures linked to the transition period (TN; 11/141; 8%) were the most likely alternative categories.

For mortalities with and without a death certificate, the numbers of immediate and underlying assignations were compared using a chi-squared or Fisher's exact test. It was less likely ($P < 0.0001$) for a death to be assigned an immediate cause if there was no death certificate (43/82; 52%) than if there was a death certificate (134/141; 95%). Similarly, it was less likely ($P < 0.0001$) for an immediate cause to be assigned an underlying cause if there was no death certificate (5/43; 12%) than if there was a death certificate (61/134; 46%). The increased likelihood of more detailed mortality codes held true even for those 7 cases with a death certificate but no necropsy. It was more likely ($P = 0.02$) for a death to be assigned an immediate cause if there was a death certificate even without a necropsy (7/7; 100%) than if there was no death certificate and no necropsy (43/82; 52%).

Depth of Detail

Documenting COD through the use of a death certificate and mortality codes expands on the typical practice of recording death according to a single, generic pathophysiologic descriptor. This increased depth of detail helps focus efforts on the urgent task of addressing rising dairy cow mortality by providing useful information for directing management strategies targeting death loss. For example, of the 7 cows described above with a death certificate but without necropsies, 2 received spinal injuries due to wedging underneath freestall partitions. Historically, such injuries have been recorded generically as "BACK", "DOWN" or some other non-standardized descriptor, and without the retention of other pertinent information. Within the current system these 2 mortalities were coded IJEYBK. This standardized the outcome to a back injury rather than allowing for variable terminology, and acknowledged the availability of a death certificate that provided additional information related to the freestall trauma.

Capturing information within a death certificate allows dairy health care managers to peel back the layers and expose pertinent details underlying a pathophysiologic descriptor. This is well demonstrated through an evaluation of the death certificates with peritonitis (16) listed as the immediate pathophysiologic cause of death (**Table 5**). These cases of peritonitis fell into 6 general categories and

Table 4. General classifications of 223 adult dairy cow deaths with and without a death certificate, and the number of cases within each intervention category assigned immediate or underlying causes.

Death certificate	General category for intervention	No. of deaths within intervention category	No. of deaths assigned an immediate cause	No. of deaths assigned an underlying cause
No	Calving trauma	1	1	0
	Human error	2	1	0
	Injury	24	10	2
	Miscellaneous	3	2	0
	Specific disease	49	27	2
	Transition	2	2	1
	Undetermined	1	0	0
	TOTAL	**82**	**43**	**5**
Yes	Calving trauma	6	6	6
	Human error	2	1	1
	Injury	19	19	9
	Miscellaneous	15	15	8
	Specific disease	80	80	28
	Transition	11	9	7
	Undetermined	8	4	2
	TOTAL	**141**	**134**	**61**

7 separate underlying issues, highlighting the potential variability underlying a particular pathologic outcome. Of note, 1 of the underlying issues (LDA) was associated with 3 separate management categories. In 1 case, toggles were used to correct the LDA which led to fulminant peritonitis and euthanasia despite necropsy demonstrating correct placement of the toggles. This case was categorized within the specific disease process category (DZ) as it was felt that the peritonitis was a stand-alone problem solely attributable to the LDA. Another of these LDA cases had focal peritonitis due to incorrect placement of toggles in the rumen. Nonetheless, an overall assessment of the situation indicated that the animal had a history of progressively debilitating early lactation diseases. The peritonitis served as the inciting event necessitating euthanasia, but the appropriate categorization accounted for the multifactorial transition failures (TN). The third case of peritonitis due to LDA was attributed to human error (HE) related to surgical correction of the LDA via a right-sided paralumbar omentopexy. Although this case could arguably have been placed within the TN category as well, the history included a novice surgeon and the decision was made to document that aspect of the outcome.

Cause of Death as a Matter of Philosophy

Human medical epidemiologists have suggested that assessing the importance of anatomical lesions as an indicator of the fundamental cause of death is more a matter of philosophy than fact.[8] Primary, secondary, and final causes of death should be viewed within the multifactorial context of the COD, and supported through postmortem diagnoses.[21] An example is the case of peritonitis secondary to placement of rumen toggles but attributed to a failed transition period; the philosophical component of mortality records speaks to the need for capturing data relevant to management. The goal is to provide standardized records that are representative, consistent, and accurate to a level that allows for meaningful decision making.

From the standpoint of human medical epidemiologists the death certificate with its CODs is at its heart a measure of public health. Health policy and resource allocation may be directed partially by the information acquired from death certificates, but measurable outcomes can take decades or more to observe. Ultimately it is the measure itself for which the death certificate is designed. For example, in the US infant mortality hovered around 1 in 3 in 1900. Today that number is closer to 6 in 1,000. Although death certificates undoubtedly contributed to this decrease over the decades, the primary indication of the importance of death certificates is that without them we would not know those numbers at all.[18]

Similar to their use in human medical epidemiology, death certificates can help dairy health care providers implement oversight and intervention strategies targeting morbidity and mortality. Within the current study, improved mortality records certainly highlighted problems needing to be addressed, yet the annual mortality percentages did not change significantly. Although some specific causes of death, such as hemorrhagic bowel syndrome, decreased in frequency over the course of this study (annual mortality percentage of 1.4% during 2014, versus 0.6% during 2015 and 2016), others such as pneumonia remained steady or even increased in frequency (annual mortality percentage of 0.6% during 2014 and 2015, versus 1.0% during 2016). This emphasizes the point that raising awareness of health concerns can help direct management solutions, but vigilance must be maintained to recognize future areas in need of assistance.

Dairy systems are complex and every implemented solution has unintended, often irreversible consequences that evolve over an extended period of time.[c] Managing such

Table 5. Additional layers of information and detail related to a pathophysiologic descriptor of an immediate cause of death (peritonitis) as provided by 16 Dairy Certificates of Death.

Immediate cause	General category	Underlying cause	Other important factors
Peritonitis	Specific disease (7)	Hardware (3)	
		LDA (1)	Toggles in place
		Metritis (1)	Severe metritis; LDA and toggle
		S. I. perforation (2)	Abscessed region (1); uterine involvement (1)
	Calving trauma (4)	Uterine tear (4)	Dystocia (2); vaginal trauma (1); bowel involvement (1)
	Human error (1)	LDA*	Surgical site abscess; metritis
	Transition (2)	LDA (1)	Toggles in rumen; history of metritis and mastitis
		Abomasal ulcer (1)	
	Miscellaneous (1)	RTA**	Necrosis and abomasitis
	Undetermined (1)		History of metritis

*left displaced abomasum

**right torsion of abomasum

a system requires flexible interventions based on ongoing assessments of underlying issues. This gets to the point of this study, which was to demonstrate the level of meaningful detail that can be gathered and captured in records for later analysis of health management outcomes on dairies. How well the health care providers on a dairy use the information to take meaningful action to address problems and decrease death risks will certainly be an important part of a dairy's story. It is extremely difficult or impossible to have a meaningful positive impact on management without the appropriate information, and the certificate of death can help provide that information in a usable form.

Discussion

Whereas human cause of death statistics generally rely on a sequence of data captured in a standardized format, dairy cow deaths have been poorly defined, marginally recorded, and rarely analyzed. In fact, the least available dairy herd data comprise records of disease and management events and are subject to tremendous variability in the rigor and consistency of their recording.[9] Current record systems can provide copious concrete data regarding life history features of dead cows, but are not configured to facilitate analysis of prior health events that result in a current condition, nor do they assess the cause and effect of various phenomena.[12] National and regional data sets derived from these record systems can be used to describe associations between mortality and population characteristics, aspects of management, and environmental factors but they are unable to predict underlying causes for specific deaths.[4,14,15,17] As with human cause of death tabulation, efforts to define underlying causes of dairy cow mortality require knowledge of the sequence of antecedent causes that eventuate in a death. Yet, antemortem medical histories on dairies are suspect and necropsies are rarely performed. Consequently, on-farm databases have historically depended on capturing relevant information regarding dead cows in broad, ill-defined categories that only partially document the reason for removal.[2,3]

Clearly, there are different levels of detail that dairies may wish to achieve regarding mortality records. The most thorough recording process can make use of a certificate of death with a CODs. A hard copy certificate for each animal that dies provides an assessment tool for review and for stimulating discussion among the various dairy personnel. The concept of a CODs with a sequence of COD (underlying, intermediate, immediate) should be considered as a means to more fully capture the continuum of events leading to a death. Ultimately, documenting mortalities in on-farm databases using a well-defined code based on a CODs and other influential factors can provide an easily analyzed assessment of mortalities that goes beyond simply recording overly generic terminology.

The process we are proposing with the use of dairy cow death certificates may look somewhat complex or time consuming, but it can be relatively fast and efficient. We believe using mortality investigations to assess dairy health management outcomes represents an opportunity for veterinary investment in cow well-being that is currently underutilized. As evidenced in this retrospective study, veterinary involvement in mortality investigations with or without necropsies can lead to more detail and depth of analysis than is provided by standard procedures and farm personnel alone. That said, although not all cows need to be examined by necropsy to utilize this approach, there is often an advantage in providing specific pathological content to the context of a death.

Based on experiences within human medical epidemiology,[1,27] the implementation of dairy certificates of death and accurate characterization of COD will require dedication on the part of producers, veterinarians, and dairy health managers interested in addressing the problem of dairy cow mortality. It is worth mentioning that the veterinarians, herd managers, and the dairy's owner involved in this study were and continue to be invested in the routine use of the death certificate to scrutinize health outcomes, and view it as an integral component of health records. Without a methodology for capturing necropsy data, veterinarians' insight, and historical perspective, the content and context surrounding a death would be lost to the system. The death certificate with its CODs and mortality codes provides this methodology and ties loose ends together. Ultimately it is the death certificate that provides the platform for ongoing assessments of mortality and underlying causes. This is important because causal reasoning is motivated reasoning, and we care about the causes we identify.[18]

With regard to dairy cow mortality the fundamental question remains: why do dairy cows die? Although there are recent calls across the industry for a greater focus and control schemes to deal with the problem of dairy cow mortality,[3,7] efforts have primarily centered on studying and analyzing the problem using limited resources and without the benefit of CODs. Endeavors to thoroughly explore underlying causes of death and to build a shared understanding of the problem require better data capture that facilitates dialogue and learning within the dairy community. Although there is no single solution to this problem, the incorporation of certificates of death with CODs into dairy record systems would be a good first step toward facilitating best intentions becoming better outcomes.

Conclusions

Issues related to establishing useful human cause of death metrics and categories also lie at the heart of research into dairy cow mortality. Dairies are complex systems consisting of multiple connected, interdependent, interacting agents. A thorough inquiry into the causative factors underlying increasing mortality on dairies requires an approach that embraces this complexity. Such an approach must provide a strategy for working within each unique system to address

problems as they evolve. Differences lie in the details related to particular herd characteristics and practices, and specific manageable outcomes including death. Ultimately, efforts to define cause of death are inherently dependent on procured data, and record systems designed to capture that data are imperative.

Endnotes

[a]Dairy Comp 305, Valley Agricultural Software, Tulare, CA
[b]Microsoft Excel, 1 Microsoft Way, Redmond, WA
[c]McConnel CS. Dairy cow mortality, PhD Dissertation, Fort Collins, Department of Clinical Sciences, Colorado State University, 2010;179.

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